JUNE 8, 1961

DESIGN

LIBEL EL' LIBEL EL' LEILA MICEGEITHE



U.S. WARIDYNE system coordinates variable speed, multi-motor range drives

Problem: Filon Plastics Corp., with a continuous automatic laminating process for making fiberglass reinforced plastic building panels, needed to maintain absolute coordination of drive motors. Speeds on each of four range drives (more than 200 feet in length) had to be adjustable without loss of coordination between motors.

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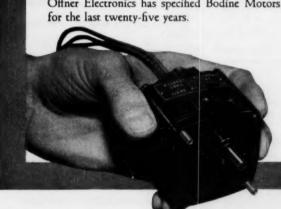


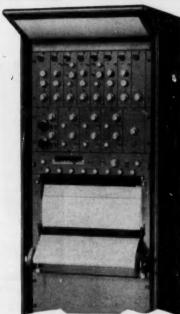
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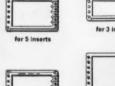
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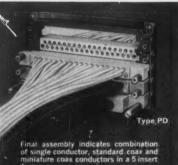
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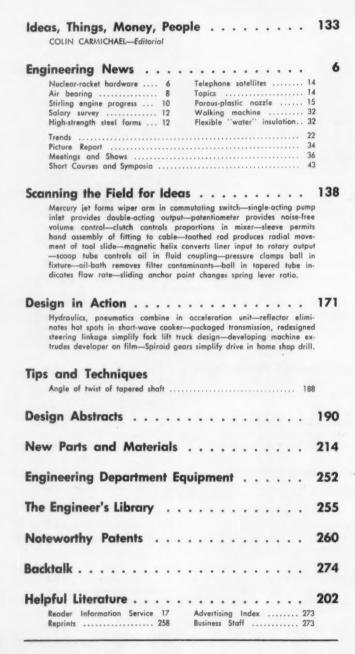
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Front Cover: Master and slave units follow each other across George Farnsworth's colorful representation of a synchro system. On Page 150, J. D. Tate gives a rundown on these positional-information indicators.

Computing with Air
designed to withstand many aerospace environmental extremes.
Potted Hydraulics
nonics, is now being doubled to the nyardune circuit of missile ingin-contol systems.
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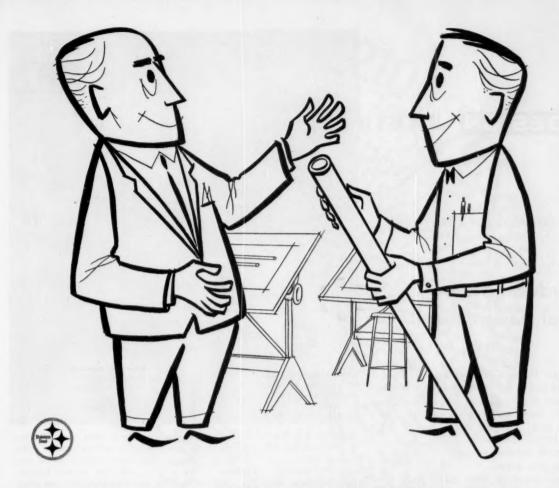


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Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



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DESIGN ENGIN

Nuclear-Rocket Program:

Hardware Nears Final Design Stage

Canoga Park, Calif.—The first flight-weight nozzle for a nuclear-rocket engine is under development at Rocketdyne Div., North American Aviation Inc. To be used later this year when the Kiwi-B tests begin, the nozzle will be the most advanced exhaust control yet conceived in the free world.

Constructed of tubes made from Inconel X, the device will handle heat loads up to ten times greater than those imposed on conventional chemical-rocket engines. More sophisticated than the

water-cooled, double-walled nozzle designed by Rocketdyne for Kiwi-A tests, it will be cooled by liquid hydrogen forced through the tubes under high pressure.

An axial-flow turbopump, the first developed for rocket engines, has now been successfully operated for more than 35,000 sec. Consisting of a turbine adapted from the Atlas ICBM program and a power-control valve that will act as a throttling device, the pump features a controlled

Bird on the Ground

Named for the New Zealand bird that cannot fly, the Kiwi program is set up to determine feasibility of a hydrogen - cooled, high - intensity, compact nuclear reactor for practical rocket propulsion. Kiwi. A primarily involved open-cycle reactor tests; Kiwi B is concerned with developing basic data for a flyable reactor.

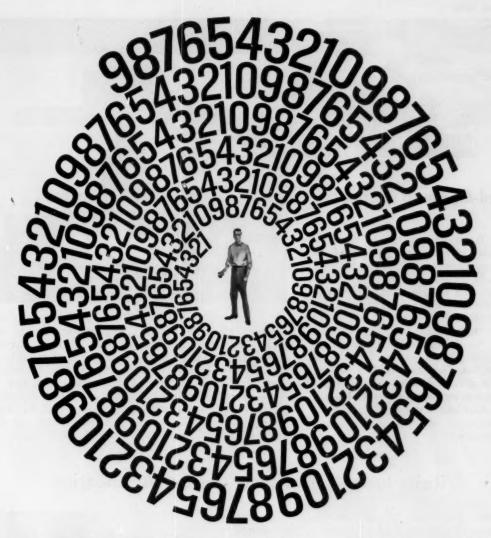


Water-cooled, double-walled nozzle used in Kiwi-A tests was the first to overcome heat-loading problems imposed by a nuclear reactor. The nuclear engines will use fission energy to convert working fluids into ultra high-temperature gases. Because the gases are nuclear heated, their molecular weight is not limited by the presence of combustion products; higher velocities, and thus thrusts, are potentially available.

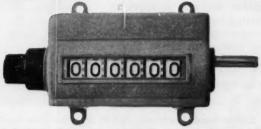
turbine speed of from 1000 to 25,000 rpm. By changing the gas-flow rate to the turbine, the valve will vary pump speed and propellant-flow rate.

Designed by Rocketdyne to provide optimum features for the high-velocity, high-pressure movement of liquid (and nearly gaseous) hydrogen, the pump will be incorporated in two propellant feed systems now being tested. The first system will supply liquid hydrogen to the reactor in Kiwi-B tests. It will be capable of passing stringent flight standards with only minimum modification. The second system will substitute a 7500-hp electric drive for the turbine. It will be used as a test-facility unit to check and evaluate performance of component units.

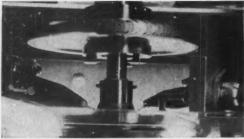
According to T. F. Dixon, the company's vice president for research and engineering, production of safe and useful nuclear rocket engines is possible now. Information developed in the Kiwi program—on reactor design and ability of the reactors to provide enough heat to convert liquid hydrogen into an effective propulsive force—has shown that "prohibitive problems" can be solved with little extension of the present state of the art.



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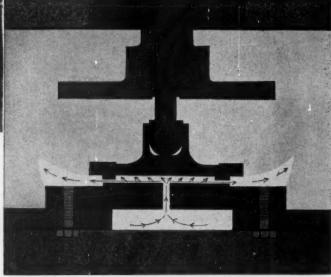
Visicounter is available in ratchet types, with speeds up to 500 counts per minute, or in geared types with up to 1,000 counts per minute. The new figures, larger and sharper, are another example of Veeder-Root design for maximum efficiency.



Trapped-Air Thrust Bearing

SEATTLE, WASH.—A new type of air-lubricated bearing, recently developed by the Boeing Co., opens new applications for this kind of minimum-friction device. An externally pressurized step bearing, it allows a load-carrying shaft to spin freely at high rpm on a cushion of compressed air.

Simpler than other externally pressurized bearings, the Boeing device uses a single, easily drilled air inlet, rather than a series of tiny orifices. Pressurized air entering the shaft housing through this one opening becomes trapped in a shallow recess. The air lifts the shaft and becomes the lubricant. The recess traps only enough air to meet load requirements.



Because air flow is throttled as it escapes from the recess (rather than at the orifices), step bearings require less complicated air-regulating equipment, according to Boeing engineers. In addition, step bearings damage less easily than orifice types.

The new bearings have been operated with shafts ranging from ½ to 5 in. diam and at speeds of up to 100,000 rpm. Ambient temperatures have ranged from -330 to 600 F. At cryogenic temperatures, one bearing was even lubricated with liquid nitrogen. The bearing operated continuously as temperature was decreased, and the nitrogen changed from gas to liquid.

Rails Judged Best New Copper Application

NEW YORK—Top honors in the 1961 Copper and Brass Achievement Awards competition (industrial div.) went to the Ringsdorff Carbon Corp. for a new current-carrying system. The competition, sponsored by the Copper & Brass Research Association, is held annually to pick the most outstanding new applications for the metal and its alloys.

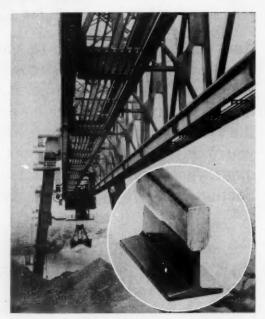
Extruded copper rails carry electrical current to fixedtrack, materials-handling equipment in the Ringsdorff system. The rails, mounted on standard steel tee bars, provide superior electrical characteristics, exceptionally high strength, and a high degree of design and installation flexibility.

Formerly, aluminum and other metals had predominated as current conductors in heavy fixed-track equipment. However, the copper rails have several advantages:

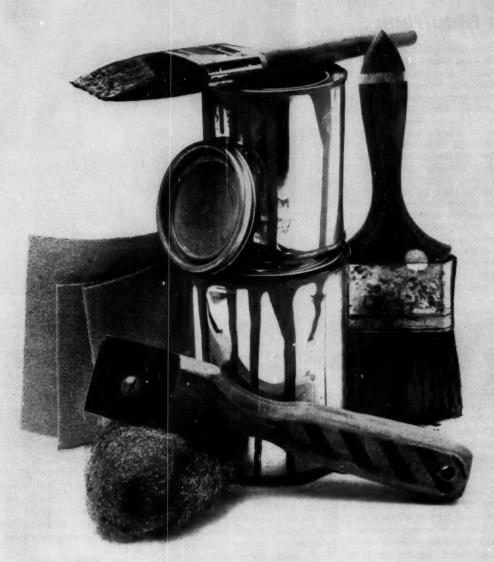
• They permit the use of carbon—the most efficient current pick-up material. Carbon lubricates itself and produces a protective film that shields the contact face of the conductor, decreasing the amount of maintenance required by the system.

 They reduce size and weight, making the system more adaptable to special engineering requirements.

 Copper has sufficient strength to resist short-circuit stresses and retain enough resilience to spring out and back when forces are applied.



Copper headed rails mounted on standard steel bars (insert) won the 1961 award for distinguished application of copper metals in industry. One version of the current-carrying system is now being installed in a steel mill. The system will use 24,000 ft of rail, will furnish cranes up to 1300-amp currents.



Who needs them anymore?

Certainly not the consumer who buys aluminum products. He doesn't need to scrape an aluminum boat or paint an aluminum lawn chair. But ease or total lack of need for maintenance is only one of the reasons more and more people are buying aluminum products. Olin Aluminum, through its engineering and design services, has helped many fabricators produce better aluminum products at far less cost. When these quality improvements and savings are passed on to the public, sales go up. Chances are, Olin can show you ways to save and translate new ideas into aluminum. Call your nearest Olin Aluminum Sales Office. The very latest technical help is on the way.



Fastest Printer/Plotter

A new printer/plotter system makes computers used in the Atlas missile program "5000 times more eloquent," according to engineers at the General Electric Co. Missile and Space Vehicle Dept. The system, designed by Briggs Div., Drexel Dynamics Corp., Norristown, Pa., accomplishes high-speed printing and plotting simultaneously at a rate of 300,000 points per min-5000 times faster than other automatic plotters and at least four times faster than the best existing computer print-out system. It translates coded digital information on a 24foot reel of magnetic tape into 500 pages of graphed and/or printed data in 8 min. Designed around an electrolytic stylus recorder and driver system, the Briggs machine contains a patchboard programming system that allows flexibility in changing system instructions. Other features include three panels of logic boards that provide styli, plot, and state control, plot decoding, and character generation.



Battelle Reports Stirling Engine Problems, Progress

COLUMBUS, OHIO—The Stirling engine—invented 145 years ago but eclipsed by the internal combustion engine—may gain new importance in the current drive for new power sources and energy-conversion devices. According to Dr. Theodor Finkelstein, Battelle Memorial Institute, the regenerative thermal machines are now "under intensive study for applications as diverse as outboard motors, infrared-cell coolers, air conditioners and pumps."

The future of regenerative thermal machines, of which the Stirling engine is the best known, ties in with that of solar and nuclear power converters. The new energy sources could make it possible to avoid material and design limitations inherent in this type of machine.

External Combustion

The Stirling engine has often been described as an "external combustion" engine. This description, Dr. Finkelstein notes, sums up the drawbacks that have caused it to be considered a historic curiosity. The main difficulty in heating regenerative machines with fossil fuels is that heat must be transferred from the outside of an enclosure, such as a cylinder wall, to the inside. Creep strength of engineering materials limits the temperature and pressure which can be used. Output is also restricted by the heat-transfer area and by the unavoidable temperature differential between the outside and

the inside.

With the nuclear and solar-energy inputs, says the Battelle scientist, the source of heat can be internal. One system, which uses the heat produced by isotope decay, locates "fuel" inside the engine structure. Similarly, it is possible to beam solar energy through a quartz window and generate heat right inside the working-fluid system. Both methods give a compact unit with practically no direct heat losses and high operating temperatures.

Regenerative engines are quite versatile and can be designed to serve as prime movers, refrigerators, or heat pumps. Their theoretical efficiencies are much higher than for more conventional engines.

One obvious application, according to Dr. Finkelstein is in space probes and satellite auxiliary power plants. Here, regenerative units have all the desired qualities of compactness, efficiency, and reliabilty. A second application, solar engines,

could be designed as simple and reliable prime movers for use in underdeveloped countries. If such machines were produced cheaply and made available in large numbers for irrigation, they might increase living standards considerably. Where natural fuels are readily available, a simple low-efficiency fool-proof power producer could be built to run on peat, vegetative waste, and other combustible material.

Power Without Noise

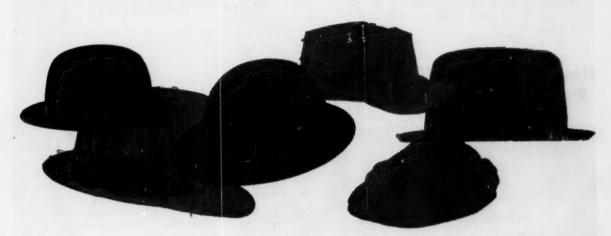
Many other applications are feasible at this stage of technical development. A power unit for small boats, for example, could use bottled gas as fuel. The almost uncanny silence of the prime mover should make it most attractive.

The use of regenerative thermal machines as road-transport power units will have to await development of a better control method with short response time. The main advantage of the engine in this application is that the property of thermodynamic reversal can be used during braking. Energy stored every time the vehicle is slowed down or stopped can be recovered during subsequent acceleration.

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NSPE Survey: Salaries Up 6.6 Per Cent Since '58

Washington — The median annual salary of NSPE members climbed to \$10,660 during 1960—up \$660 from '58. Ninety per cent of these engineers now earn more than \$7140, three quarters top \$8580, and one out of four commands \$13,750 or more. Only the upper decile, \$19,680, has failed to increase since '58.

Over 24,000 members responded to the 1960 National Society of Professional Engineers income and salary survey, a return of 40 per cent. The data reported are based on preliminary tabulations; the full survey won't be published until later this summer.

In 1958, returns were received from 18,713 members. The large increase is partly due to the inclusion of introductor members in the survey. Many of these engineers worked less than a full year.

Year Entered Engineering	***************************************		nual Salary —— per year)	
Profession	'60 Survey	'58 Survey	'56 Survey	'54 Survey
1960	5,620*			
1959	6,820			
1958	7,270	5,830		
1957	7,690 7,980	6,490 6,750	E 000	
15 .	7,980	6,750	5,060	
305	8,590	7.380	6.270	
1954	8,870	7,420	6,300	
1953	9,200	7,710	6,420	5,000
1951-52	9,790	8,590	7,180	5,570
1949-50	10,500	9,110	7,840	6,460
1947-48	11,300	9.950	8,640	7.110
1945-46	11,440	10,170	9,140	7,570
1943-44	12,400	10,980	9,740	7,890
1940-42	12,910	11,490	10,250	8,820
1935-39	13,630	12,550	11,450	9,700
1930-34	14.940	13.270	12.020	10,780
1925-29	14,920	13,930	12,330	11,120
1920-24	15,580	14,180	13,130	12,360
1915-19	12,810	13,600	12,210	11,080
Before				
1915	13,000	12,670	12,060	10,500

^{*}Includes respondents working less than full year.

New Shapes in Alloy Steels

USS Rolls Off-the-Shelf T-1 Forms



Heat treated to three times the strength of structural carbon steel, the shaped alloys come out of the austenitizing furnace (above) and are immediately transferred to a quenching fixture (right). Water quenching requires special fixtures that clamp the shapes firmly to prevent distortion during the rapid-cooling cycle. The waffle-like pattern formed by the upper and lower fixture segments permits full flow of water to uniformly quench all areas of the alloy-steel channel. After quenching, the rolled shapes are tempered.

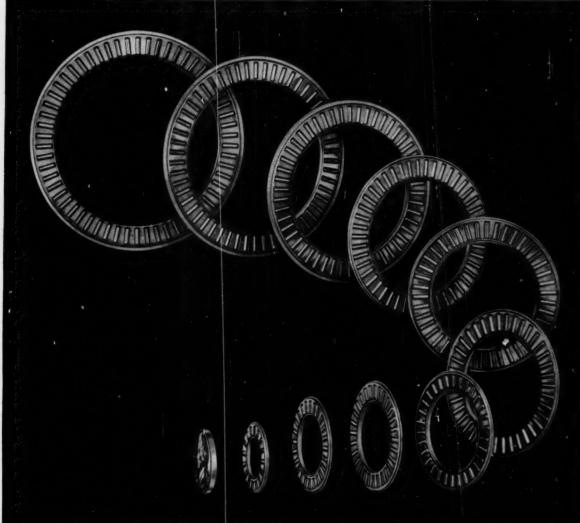


PITTSBURGH — Rolled channels, Ibeams, and angles can now be commercially produced from quenched and tempered alloy steel. According to United States Steel Corp., developer of the new shapes, users will no longer have to cut the alloy plates and weld their own structural sections.

A steel-industry "first," the alloy shapes promise weight and cost savings in a host of applications. And because some small shapes are impractical to weld, the rolled sections could open up new design uses for alloys.

Furnished in lengths up to 40 ft, the shapes are produced in several alloys, including USS "T-1" and "T-1" type A constructional alloy steels, 9 per cent nickel steel for cryogenic applications, and HY-80 naval armor. According to Frank T. Bumbaugh, U. S. Steel's manager of alloy products sales: "Designers can now specify offthe-shelf shapes of 'T-1' steel which have a minimum yield strength of 100,000 psi-about three times that of structural carbon steel. The shapes have the same toughness and weldability as "T-1" steel plates, which have virtually revolutionized the design of pressure vessels and many types of earthmoving, mining, and transportation equipment."

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Bell Stresses Reliability In Telephone-Satellite Program

NEW YORK—Thousands of pieces of synthetic sapphire will cover the communications satellites now being developed by Bell Telephone Laboratories. Designed to protect solar cells from space radiation, the sapphires will enable "working" satellites to endure the rigors of space for ten years or more.

Sapphire protection is only one example of the measures being taken to obtain high reliability, Dr. James B. Fisk, president of BTL, said at the recent meeting of the American Iron and Steel Institute. Bell engineers are using the approach they evolved for submarine-cable systems—some 1500 electron tubes have functioned properly under the oceans for the past two to six years without a single failure.

In the satellite program, each individual component is being developed so carefully that its predicted life will be far greater than what is re-

quired of the over-all system. To this end, the program has been divided into four phases:

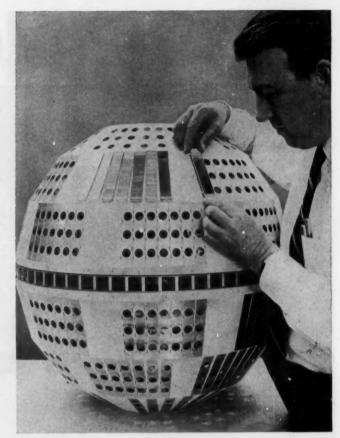
• Study the space environment and define all the conditions and hazards.

 Artificially simulate the environment and intensify the hazards to make components fail.

 Redesign until reliability of a required component can be accurately predicted.

 Conduct a real-life test program to confirm that the system performs as predicted.

At present, there is a pressing need for actual life tests in space. Bell engineers plan to use the first telephone satellite to obtain additional data and check out components planned for future systems.



Roughly spherical, the first telephone satellite will have up to 60 flat surfaces. Slices of sapphire were chosen to protect the solar cells because the man-made gems will stop electrons, reduce proton bombardment, and resist erosion by micrometeorites. In addition, the transparent sapphire shields, set in platinum frames, will convey heat away from the cells when the satellite is exposed to long periods of direct sunlight. Rapid and extreme temperature changes will have little effect on the shields since expansion coefficients of platinum and sapphire are similar.

Topics

Family toothbrush is a motorized unit (with interchangeable brushes) that does the job in only 45 seconds instead of the three minutes required with a hand-powered model. A 110-v motor oscillates the brush 60 times a second—very good for the gums, according to dentists who tested the machine. The electric brush is called Broxodent and is made by E. R. Squibb & Sons, division of Olin Mathieson Chemical Corp.

Electricity from corn cobs, peanut shells, sawdust, and other refuse could be produced as efficiently as in a modern powerplant. This is the opinion of Dr. Frederick D. Sisler, who has generated electricity in a "biochemical" fuel cell. In two test tubes, Dr. Sisler uses sea water, carbohydrates (the basic fuel), bacteria which serve as a catalyst or igniting agent, oxygen, and positive and negative electrodes to produce electricity. Using energy of decomposition of waste products, instead of oxygen and hydrogen, removes a primary deterrent—cost—to commercial application of fuel cells.

Women drivers are better than men—or they may be in space. At the Martin Co., Baltimore, simulated space flights—equal to millions of miles—have been made in connection with Project Apollo, which proposes to have a space crew orbit the earth and the moon, then land on the moon.

Primary purpose of Martin's research is to study space-vehicle control, particularly the problem of bringing two craft together on the same course and speed in oribt. The ladies—who may have trouble parking a car near the curb—seem to catch on to the space rendezvous controls faster than men. They usually come alongside the other vehicle on the first or second try.

Portable oxygen supply—to carry in a car, boat, plane, or strapped to a golf bag—is introduced by the NCG Div. of Chemetron Corp. The NCG-Metrox weighs 10½ lb, including carrying case and mask. It supplies 51 minutes of oxygen at a flow rate of 3 to 12 liters a minute.

Rocket Nozzle Perspires To Hold Down Wall Heat

Varying Porosity Plastic Ablates If Temperature Rises

Hampton, S. C.—"Sweat-cooling" of rocket nozzles is now a realizable possibility. Heat-resistant plastics with controllable porosities, developed by Westinghouse Electric Corp., Micarta Div., allow designers to vary porosity from section to section of a nozzle. This provides greater cooling in the throat than in the divergent section.

Although transpiration cooling is not a new concept for heat control, development of a practical rocket nozzle based on the principle has not previously been successful. Lack of control of porosity has frustrated former attempts to make nozzles of porous graphite or sintered metal.

The cooling method involves forcing a fluid into a nozzle through porous walls. Cooling is produced by rapid evaporation of the fluid on inside surfaces in contact with the exhaust flame. Two other phenomena aid in reducing temperature of the wall in contact with the exhaust: 1. Heat is absorbed by the fluid flowing through the wall, retarding heat passage outward. 2. A film is formed on the inside wall of the nozzle, reducing conduction.

Fail-Safe Ablation

The porous material developed by Westinghouse can be made of glass, leached-glass, or quartz fabric having a high-temperature phenolicresin binder. It would have the additional fail-safe feature of ablating if the coolant system failed. The high strength/density ratio of the porous, laminated structure is more than sufficient to offset thrust and hoop-stresses, as well as vibrational effects produced by a rocket exhaust.

A laboratory-scale structure cooled by water was subjected to an oxyacetylene cutting torch. After a three-minute application of the flame, the exposed surface showed only superficial effects. A similar sample, without coolant, was ablated to a depth of approximately ½ inch in only one minute.



This submarine periscope support bearing custom engineered by ITI for Nortronics, a division of Northrop Corporation, is indicative of today's changing bearing concept. By designing limit stop lugs as an integral part of the 17-7 PH stainless steel raceways, available periscope azimuth sweep was increased from 200 to 300 degrees. This is just one example of how engineers are turning to special bearings to solve the formidable problems created by advanced mechanical design. Materials, proportion and geometry may be altered to minimize weight or space, to permit operation at extreme temperatures, or without lubrication. For information on how ITI can design and produce in any quantity other special bearings write for Bulletin AFB-2.



INDUSTRIAL TECTONICS, INC.

manufacturers of precision balls and bearings
BEARING DIVISION 18301 SANTA FE AVENUE, COMPTON 13, CALIF.

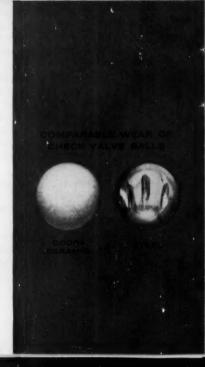


Tolerances up to 0.000020" can be obtained on Coors high alumina spherically ground balls. Tolerances remain constant at cryogenic, room or elevated temperatures, because the material is dimensionally stable over a wide temperature range. Applications for Coors spherically ground balls include bearings, gauges and check valves. Coors high alumina ceramics are hard (Rockwell 45N 75-81) and extremely wear resistant—over 240,000 psi to over 350,000 psi compressive strength—completely homogeneous—chemically inert—non-magnetic—less than half the weight of steel, less than one-fourth the weight of tungsten carbide. Spherically ground balls, spherical within 0.0001", are kept in stock covering a wide range of sizes. Write for Data Sheet No. 5004. Regional Sales Managers: West Coast, William S. Smith, Jr., EM 6-8129, Redwood City, Calif.; Midwest, John E. Marozeck, FR 2-7100, Chicago, Ill.; Central, Donald Dobbins, GL 4-9638, Canton, Ohio; East Coast, John J. McManus, MA 7-3996, Manhasset, N. Y.; New England, Warren G. McDonald, FR 4-0663, Schenectady, N. Y.; Southwest, Kenneth R. Lundy, DA 7-3716, Dallas, Texas; Oli Field Industry, William H. Ramsey, UN 4-6369, Houston, Texas.



ALUMINA CERAMICS

Circle 212 on Page 19 Coors Porcelain Company





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HELPFUL LITERATURE

Descriptions of items start on Page 202. Starred items are from May 25 issue.

Electrical, Electronic

- 502 Tachometer Generators. 12 pp. General Electric

- Co.

 505 Polar Relays, 12 pp. Industrial Products Div.,
 Automatic Electric Soles Corp.
 507 Thermoelectricity Developments. 4 pp. Harco
 Laboratories Inc.
 508 Commercial Thermostats. 4 pp. Stevens Mfg.

- Moror Application votes, to pp. Colons, Steel Products Div., Indiana General Corp.

 Helding-Magnet Design. 4 pp. Indiana Steel Products Div., Indiana General Corp.

 Hastruments and Components. 4 pp. Packard Bell Electronics.

 Variable-Speed Drives. 112 pp. Sterling Electric Motors Inc.
- Motors Inc.
 Precision Resister. 4 pp. Rotohmeters Inc.
 Mercury-Wetted Contact Relay. 4 pp. Industrial
 Products Div., Automatic Electric Sales Corp.
- 603 Multispeed Motors.* Discusses principal types— variable-torque, constant-torque, constant horse-power. Bulletin 1300, 4 pp. Century Electric
- Co.

 Electronic Preducts.* Short-form catalog on new-product developments. 6 pp. Electronic Tube Div., Burroughs Corp.

 Power Supplies.* Design principles of complete line of dc power supplies. Catalog PS 361, 15 pp. Valor Instruments Inc.

 Terque Motors.* With ratings from 1.5 to 96 oz-ff. Bulletin 208A, 48 pp. Ohio Electric Mfg.

- 606 Torque Motors." With ratings from 1.5 to 96 oz. fr. Bulletin 208A, 48 pp. Ohio Electric Mfg.
 607 Tubular Capacitors." Covers film dielectric copocitors, rated 100 through 600 v in tolerances of +20, ±10, ±5v. Bulletin GEZ-3278, General Electric Co.
 608 Control Meters." Engineering Fact File provides data on contactless electronic control meters.
 12 pp. International Instruments Inc.
 609 Caszial Switches, Releys." Technical data on standard DK coaxial switches and relays. Catalog DK 61, 28 pp. RF Products, Div., Amphenol-Borg Electronics.
 610 Paper Capacitors." Physical, electrical characteristics of metallized units which operate to 125 C without voltage derating. Catalog 13188, 6 pp. Aerovox Corp.
 611 Strain-Gage Wiring Terminals." Contains characteristics, specifications, and photographs. Bulletin 4340, 4 pp. Electronic & Instrumentation Div., Baldwin-Lima-Hamilton Corp.
 612 Temperature Transducers." Describes platinum resistance transducers for use with cryogenic fluids of many types. Bulletin 2000, 8 pp. Trans-Sonics Inc.
 613 Servo-Accelerometers." Covers Model 4310 transistorized, 0.1 per cent linear force balance units. 4 pp. Donner Scientific Co.
 615 Panel Meters." Data Sheet describes Style 65 4 x 6 in. rectangular meters, lists modifications. 4 pp. Helipol Div., Beckman Instruments Inc..
 616 Multiple Lump Indicaters." Detailed data on

- Inc. 616 Multiple Lamp Indicators.* Detailed data on

Telestrips, embodying from 2 to 20 lamp-holders. 8 pp. Dialight Corp.

Hydraulic, Pneumatic

- 501 Valves, Baffles, Traps. 28 pp. Consolidated Vacuum Corp.
 514 Centrifugal Pumps. 8 pp. Goulds Pumps Inc.
 516 Rolling Diaphragms. 26 pp. Bellofram Corp.
 520 Oil-Level Goges. 6 pp. Federal Brass Mfg. Co.
 525 Air, Hydraulic Cylinders. 6 pp. Sheffer Corp.
 527 Hose Ends. 2 pp. Parker Fittings & Hose Div., Parker-Honnifin Corp.
 532 Air-Central Valves. 4 pp. Honnifin Co., Div., Parker-Honnifin Corp.

- 532 Air-Control Valves. 4 pp. Hannitin Co., Div., Porker-Hannifin Corp. 535 Urethene Seals and Packings. 8 pp. Disogrin Industries Div., Pellon Corp. 537 Small Pumps. 2 pp. Moyno Pumps Div., Rob-bins & Myers Inc. 542 Meters, Compressors, Pumps. 12 pp. Gast Mfg.

- 617 Magnetic Oil Filters.* In capacities of 1 and 5 apm. 4 pp. Sinclair Machine Products Inc.

 618 Ball Valves.* In seven sizes from ¼ to 2 In.
 Bulletin 712-361, 6 pp. Hydromatics Inc.
 619 Piestic Protecters.* For cap or plug application and male of female threads or tubina.
 Bulletin P-6104-GP, 4 pp. Plostics Dept., S. 3.
 White Industrial Div.
 620 Elestomer-Fabric Diaphragms.* Long stroke, rolling, preconvoluted, molded convolution units for static or dynamic applications. Form DI-100, 4 pp. Diaphragm Industries Inc.
 612 Silicene-Rubber Seals.* Standard silicone, fluorosilicone, and fluorocarbon-rubber seal constructions. Catalog 1, 42 pp. Connecticut Hard Rubber Co.
 622 Flexible Hose Assemblies.* Fluoroflex-T assemblies for service from -67 to +450 F.
 623 Hydraulic, Pneumatic Equipment.* Valves, cylinders, accessories, pumps, special controls. Bulletin 91051, 6 pp. Airmatic Valve Inc.
 624 Pneumatic Products.* Engineering data on compressed-air-line filters, pressure regulators, lubricators, valves. Catalog 1000, 70 pp. C. A.
 Norgren Inc.
 625 Leether Packines.* V and U-units for hydraulic.

- Norgen Inc.

 Norgen Inc.

 625 Learther Packings.* V and U-units for hydraulic and pneumatic applications. 4 pp. Auburn Mfg. C.

Mechanical Equipment

- 503 V-Belt Drives. 64 pp. Ft. Worth Steel & Ma-
- chinery Co. 504 Brenze Bearings. 18 pp. Northfield Precision
- 304 Breaze Bearings. 18 pp. Northrield Precision instrument Corp. 510 Side-Ber Chein. 4 pp. Acme Chain Corp. 517 Chain-Prive Selection. 12 pp. Chain Belt Co. 536 Magnetic-Particle Clutch. 6 pp. Electric Prod-ucts Div., Vickers Inc.
- 626 Tape, Film Drive Sprockets.* Gives diagrams and dimensional tables. Brochure SP-52, 8 pp. LaVezzi Machine Works.
 627 Flexible Couplings.* Specifications for ten types of power-drive couplings. Bulletin J-23, 4 pp. Dept. FC, Hewitt-Robins Co. 628 Spring Design.* Issue of "Mainspring" gives data on interlock garter springs. 8 pp. Assodata

ciated Spring Corp. 629 Takeup Units.* In seven frame styles, with sleeve, ball, or roller bearings. Book 2741, 16 pp. Dept. PR, Link-Belt Co.

Assembly Components

- 638 Set Screw.* Covers Unbrako high-torque units.
 Form 2067, 8 pp. Standard Pressed Steel Co.
 631 Retaining Rings.* Specifications on Series 1000, 3000, 3100. Industrial Retaining Ring Co.
 632 Rivets.* Bifurcated, deep-drilled, semitubular, and shouldered units stressed. 4 pp. Judson L.
 Thomson Mfg. Co.

Manufacturing Processes, Parts

- 513 Dip Brazing. 8 pp. Precision Dipbraze Inc. 506 Anticorrosion Treatment. 8 pp. Corrosion Re-action Consultants Inc.
- 633 Electroplating Processes.* Covers 19 plating and other metal-finishing processes. Bulletin EP-103, 24 pp. Hanson-Van Winkle-Munning

Materials

- 518 Steel and Plastic Tubing, 4 pp. Joseph T. Ryerson & Son Inc. 521 Bearing Steels. 4 pp. Aetna Ball & Roller Bearing Co., Div., Parkersburg-Aetna Carp. 523 Preallayed Powders. 4 pp. Hoeganaes Spange Iron Carp. 524 Preplated Metals. 8 pp., plus samples. Ameri-

- con Nickelaid Co. 528 Copper-Clad Laminutes. 6 pp. Synthane Corp. 531 Synthetic Supphire. 4 pp. Industrial Sapphire
- 533 Metal Coatings. 4 pp. Bee Chemical Co.
- 634 Basic Metals.* Periodic "News Digest" covers metals, their applications, and special ma-chinery. 8 pp. Dept. RDT, National-Standard

- chinery. 8 pp. Dept. RDT, National-Standard
 Co.
 6.35 Plastic Ceaties.* Pfoudlon 301 plastic cooting
 for metal. Bulletin 1007, 4 pp. Pfoudler Div.,
 Pfaudler Parmutit Inc.
 6.36 Expanded Metals.* Data on 38 decorative,
 expanded-metal designs. Catalog 61, 34 pp.
 Designers Metals Div., Southern Electric Inc.
 6.37 Zircenium Corresion Resistence.* Graphs of over
 100 corrosive media in concentrations to 100
 par cent, temperatures to 400 F. 14 pp.
 Zirconium Assn.
 6.38 Industrial Laminates.* Texolite laminates in
 copper-clad, sheets, tubes, and rods. Catalog
 L-DLL-514, 16 pp. Laminated Products Dept.,
 Section 15, General Electric Co.
 6.39 Epszy Insulation.* Properties, selection of various electrical insulating compounds. Bulletin
 E-100, 6 pp. Electrical Insulation Div., Hysol
 Corp.
- Corp.

 40 Industrial Coatings.* Covers 18 industrial coatings for all types of metal-using industries. Bulletin 4071, 4 pp. Service Products Div., S. C. Johnson & Son Inc.

Engineering Dept. Equipment

- 519 Leberatery Oscillascope. 8 pp. Tektronix Inc.
- 534 Digital Recorder. 6 pp. Industrial Systems Div., Minacapolis-Honeywell Regulator Co.
- 541 Recorder-Reproducer. 4 pp. Mnematron Corp.
- 543 Semiconductor Test Sets. 4 pp. Owen Laboratories Inc.
- 641 Profile Recorder.* Proficorder measures round-ness, flatness, roughness, waviness, scratches, flows, total surface profiles. 8 pp. Micro-metrical Mfg. Co.
- 642 Tables and Formulas.* Tables of weights, measures; mathematical symbols; Greak alphabet; temperature conversions; powers of numbers, etc. 32 pp., pocker-size. Industrial Products Div., Automatic Electric Co.

Circle the item number for information on products advertised or described, literature offered. copies of editorial articles.

NEW PARTS MATERIALS ENGINEERING EQUIPMENT

Electrical, Electronic

- 547 Constant-speed meter has wide range of output speeds. Amglo Corp.
- 553 Encesed photovoltale cells for high output and application. Weston Instruments Div., Daystrom
- Trisser tube is equipped with two starters. Semiconductor & Special Purpose Tube Div., Amperex Electronic Corp.
- 558 Plus and receptacle has 3 to 60 circuit connections. Molex Products Co.
- 366 Minieture gearmeter is permanent-magnet type for dc operation. Carter Mater Co.
- 548 Carbon film resistors are rated 1/10 and 1/8 w. Pyrofilm Resistor Co. Inc.
- 371 Electric vibratery maters are available in three units. Syncro Corp.
- 573 lassisted sleeving is furnished on cards with odhesive-backed tapes. Manger Electric Inc. 576 Pushbutten switch lights are keyboard-type units. Pendar Inc.
- San Protective caps fit three-point bayonet con-nectors. Nu-Line Industries Inc.
- 384 Right-engle gearmeters are 1/2 through 1/3-hp units. Reliance Electric & Engineering Co. 385 Precision petentiometer in bushing, servo, or topped-hole mounting types. Clarostat Mfg. Co.
- 586 Panel meters, indicators in 1 and 11/2 in. sizes. International instruments inc.
- 587 Ministere seleneld for applications as low as —420 F. Electroid Corp.
- Brushless frequency converter provides 2.5 kva output. Georator Corp.
- 592 Linear actuater incorporates strake to 6 in. Skinner Precision Industries Inc.
- Class zener diedes furnished in 28 types have 3.3 to 30-y range, international Rectifier Corp. 597 Magnetic reed switch has glass length of 1/2 in. Gordos Corp.
- Hydraulic, Pneumatic
- 545 Static seal has Teflan primary unit. Pall Corp.
- 548 Pasumatic bleed valve withstands 14,000 psi pressure. Benbow Mfg. Corp.
- 550 Werm-geer lebricants provide high viscosity in-dex. Shear-Speed Chemical Products, Div., Mich-

- igan Tool Co.
- 552 Toggle valve incorporates handle showing open or closed position. Republic Mfg. Co.
- 554 Spiral-wound sasket operates at temperatures from 1250 to 1900 F. Garlock Inc.
- 559 Small blewer wheels have four diameters from 434 to 81/2 in. Blower Div., Lau Blower Co.
- 562 Bearing grease for high and low-temperature use. Bearing Inspection Inc.
- 563 Small G-rings have flash held to 0.001 in. A. P. M. Corp.
- 564 Retating bellows seel incorporates pressuretight bellows. Sealol Inc.
- 567 Ministure filter system is powered by 1/40-hp, continuous-duty motor. Sethco Mfg. Corp.
- 569 Rigid tube coupling accommodates liquids and gases to 700 F. Resistoflex Corp.
- 570 Ministure serve valve is compatible with all known hydraulic fluids. Instrumentation & Con-trol Systems Dept., Sanders Associates Inc.
- 575 Subfractional-hp blowers now have unitized housing. Heinze Electric Co.
- 578 Air bees is helically coiled to retract when stored. Synflex Products Div., Samuel Moore &
- 582 Nose fitting requires no adapter. Lenz Co.
- 583 Hydraulic cylinders operate to 2000 psi pressure. Sheffer Corp.
- 589 Limit valve has adjustable bleed duration. Mead Specialties Co.
- 591 Hydraulic bose withstands minimum pressure of 50,000 psl. Anchor Coupling Co. Inc.
- 595 Hydraulic cylinders in 1½, 2, and 2½ in. bore sizes. Precision Hydraulic Div., Owatonna Tool Co.

Mechanical Equipment

- 549 Instrument differentials provide clearance circles to V_2 in. or less. Instru-Lec Corp.
- 561 Idler sprockets for roller-chain drives. Diamond Chain Co. Inc. 572 Sprockets and hubs for high and low-speed operation. Dayton Rogers Mfg. Co.
- 577 Magnetic clutch features three operating modes. Elm Instrument Corp.
- 590 Air-cooled engine has high piston displacement. Air-Cooled Industrial Div., Continental Motors Corp.

Descriptions start on Page 214.

594 Speed reducer has extreme input-output latitude. Planet Instrument Inc.

Assembly Components

- 544 Add-subtract counter for instruments and camputers utilizes internal gearing. Meliand Gear & Instrument Co. Inc.
- 551 Nylon clamp provides temporary and permanent cable assembly. Weckesser Co. Inc.
- 555 Small-diameter nut for ball-bearing screw as-semblies. Saginaw Steering Gear Div., General

Materials

- 546 Epoxy eshesive cures in 60 sec at room temperature. Allaco Products.
 536 Spray-on viyal flaishes for application to phosphated steel, aluminum. Coatings Div., Metal & Thermit Corp.
- 560 Paper-base phenolic rod has high strength and good machinability. Richardson Co.
- 565 Heat-stable leminate has high dimensional sta-bility. Glastic Corp.
- 574 Neopreus dhesive bonds similar and dissimilar materials. Mogic Iron Cement Co. Inc.
 579 Rigid pelyurethane foam has closely controlled dielectric properties. PolyStructures Inc.
- Aluminum fell ceatings can be bent, cut, flexed, creased, formed. Foll Div., Revere Copper & Brass Inc.
- Fluore-elastomer resists oxidation and weathering. Plastics & Synthetics Div., U. S. Stoneware Co.

Engineering Dept. Equipment

- 598 Welduble strain seges provide stability from cryogenic to 750 F temperature. Electronics & instrumentation Div., Baldwin-Limo-Hamilton
- 599 Temperature recorder for temperatures from 500 to 2500 F. Rustrak Instrument Co.
- 600 Drawing tables, desks provide co-ordinated working units. Stacor Equipment Co.
- Pressure transducer measures absolute end gage pressures from 0-5 to 0-5000 psi. Statham Instruments Inc.
- 602 Transistorized recorder provides magnetic flow-meter, ac potentiometer. Fischer & Porter Co.

EDITORIAL ARTICLES

Single copies of the following articles are available as long as the supply lasts. Starred items are from previous issues. See Page 258 for other available reprints. Editorial content of Machine Design is indexed in the Applied Science & Technology Index and the Engineering Index, both available in libraries. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor,

- Competing with Air. Use of pneumatics in new digital computers which offer high pack-oging density. (4 pp.)

 Petted Hydraulics. "'Potting" adapted to the hydraulic circuit of missile flight-control systems. (2 pp.)
- Terms. (2 pp.)
 The Engineering Department's Personality. Assessing the composite personality to locate organizational strengths and weaknesses, and to aid in planning and decision-makins.
- Clearence in Rolling Bearings. Calculation of

- probable bearing life for any amount of di-ametral clearance or preload. (5 pp.)
- 12-5 Synchro Systems. Advantages and limitations of synchro devices; use and applications. (6 pp.) 12-6 Nonstandard Crossed Helical Gears. How to use an extension of basic helical-gear design practices to get many rotios from a single pair of blank sizes. (8 pp.)
- 12-7 Commercial Success of Patents. Courts' use of commercial-success yardstick in evaluating the patentability of a new invention. (1 p.)
- Preventing Fatigue Failures—Part 4. How surface condition and environment affect fatigue life of a part. (6 pp.)
- Least-Squares Lines. Techniques for assessing the statistical significance of line drawn through a series of scattered data points.
- 12-10 Simple-Span Rigid Frames, Simplified approach to colculating the forces and couples in a rigid frame. (4 pp.)
- Fatigue Life of Ball Bearings (Abstract). Effect of lubricants on bearing life. (2 pp.)
- Measuring the Engineer. Newest methods of aprillude appraisal, procedure for doing the job efficiently. (6 pp.)
 Design Consideration for Small Neusings.* Machanical requirements for electrical housings; illustrations of typical examples. (2 pp.)

- 11-5 Seals for Hard Vacuums.* Design concepts, study results on materials for hard-vacuum, reusable seals. (6 pp.)
- Shock-Demping Calculations.* Mounting-system response to step-velocity shock; simplifying calculations and adjusting dempischaracteristics to meet input-shock specifica-

- Tions. (5 pp.)
 Push-Pull Centrels.* Avoilable types, selection factors, and design practices. (8 pp.)
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 Chemically Milled Structures.* Advantages and disadvantages of chemical milling, design of chemically milled parts. (9 pp.)
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 Pressure Resulators.* Basic principles and types; selection and applications; selection and application. (5 pp.)
 Elastic-Bedy Mechanics.* New principles in using elastic properties of materials to solve design problems. (7 pp.)
 Melicel Spring Design.* A direct design procedure that eliminates trial and error. (3 pp.)
 Internal-Combustion Engines.* Factors in se-

- Internal-Combustion Engines.* Factors in selecting engines up to 60 hp in size. (9 pp.)
- Cenical-Disc Springs.* Designing for specific characteristics in minimum space. (5 pp.)

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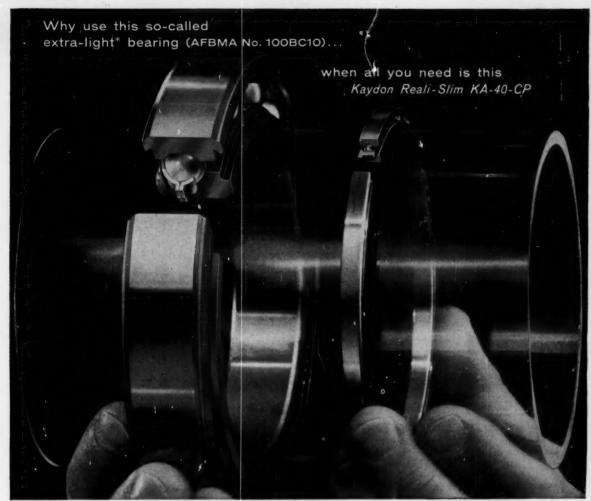
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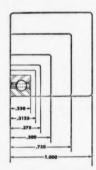
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On the heels of a 500% sales increase...

Kaydon reduces Reali-Slim bearing off-the-shelf prices additional 24%



eFive of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above. Due to advantages made possible by greater sales and increased production efficiency, Kaydon now passes along another price reduction on "off-the-shelf" Reali-Slim Type CP Bearings. This new price cut (up to 24%) has been made in addition to reductions up to 76% a year ago.

More than 80% of all present standard "extralight" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section remain the same for all bearing sizes in any one series,

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ½" width and cross section. Result: new opportunity to save on cost, size, and weight... in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — 1/4" to 1" width and cross section. Write for free, fact-filled "CP" bearing bulletin — with prices!

THE KAYDON

ENGINEERING CORP.

AN WAYDON

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160R2

materials

Imported Plastic Has Varied Potentialities

Porous polyethylene is being introduced in the U. S. by its manufacturer, Porous Plastics Ltd., Dagenham Dock, Essex, England. The material, Vyon, has excellent, uniform permeability which can be controlled to suit the application. Other qualities are light weight, flexibility, and strength. It is easily machined and fabricated, easy to clean, and noncorrosive. Suggested as an ideal filter material, Vyon has no detachable fibers.

Data Gap Delays Plastic Ships

Reinforced plastics, now a common material for small boats, could move up to the ocean-liner class, according to speculation by a panel discussing the forthcoming International Plastics Exhibition and Convention. This type of material is available with correct strength-to-weight ratios for a ship's superstructure; however, ship designers lack knowledge of stresses for large-size reinforced-plastic structures. Design techniques different from those used with metals will have to be developed, and actual structures will have to be built and tested before reinforced-plastics are actually specified.

STRONG FREE-MACHINING STEEL PLATE, USS Fremax 45 has relatively high tensile strength and yield point. Carbon content is 0.4 to 0.5 per cent. The new U. S. Steel Corp. material can be milled rapidly, broached without peeling, and drilled and tapped clean.

A NEW ZINC-ALUMINUM COATING, for powder flame spraying, provides protection against corrosion in applications where neither of the two metals would be suitable. The powder, Berkalloy, is a product of F. W. Berk & Co. Ltd., London.

products/processes



GE Produces 'Practical' Thermionic Converter

A vapor thermionic converter with 15 to 17 per cent efficiency can be produced reliably and in quantity for space and other special military applications, according to the General Electric Co. A power output of 23 w was obtained at 1530 C, and the converter produced 4.6 w per sq cm of cathode surface. Previously, GE's vapor thermionic converter was operated at reduced temperatures of 1330 C, and it produced 12 w.

Compacts Enter the Radiation-Source Field

Three types of small radiation-source machines are announced by Hughes Aircraft Co. They are: 1. A monopulse linear accelerator, about the size of an office desk and capable of producing high-intensity gamma radiation in short pulses. 2. A steady-state linac of similar compactness and output. 3. A small cyclotron. The monopulse linac can produce gamma pulses singly or as frequently as one per second; the steady-state linac can be used for radiography of large items such as steel castings, rocket engines, or solid propellants; the cyclotron is an inexpensive source of short-lived radioisotopes.

Cerebral Salesmen

On occasion, the tremendous concentration of engineering and scientific talent in the aircraft industry poses a serious problem: Companies are faced with an excess of capability in manpower and facilities. One solution to this quandry is to sell the excess ability to companies who need it. General Dynamic's Convair Div., for example, has just sent forth a contingent of "scientific salesmen." Their product: Convair's ability to create and design new products and equipment which will complement or add to a company's prime products.

Nuclear Engineering for the Undergraduate

The degree of bachelor of science, nuclear engineering, will be offered by the University of Wisconsin beginning next fall. In the new curriculum, 40 to 44 per cent of the student's classes will be in basic sciences, 40 to 44 per cent in engineering, and 16 to 20 per cent in non-technical courses. When UW's nuclear engineering program was initiated three years ago, only masters' degrees were granted; a year ago the graduate program was extended to grant Ph.D. degrees also.



electronics

NICKNAMED PROJECT BRAIN (Air Force calls it "a study of Nuerobiological Data Acquisition"), a new research effort is looking into the possibilities of controlling an electromechanical servo with signals generated in the human nerve network. First-order problem in such man-machine coupling is how to extract a meaningful signal from the noise level, says EPSCO Inc., holder of the study contract.

A SOLID-STATE COMPUTER MEMORY that stores 1-mm light spots by "persistent internal polarization" looks promising to the Office of Naval Research. Written on a thin phosphor film by 2-microsec light flashes, information bits can be read off (in yes or no form) in a fraction of a microsecond. Study of the p.i.p. phenomenon is being carried out at New York University with ONR support.

aero/space

Party-Line Satellite

Satellite Relay—NASA's fast-talking (active) follow-up to the passive Echo—will be built by Radio Corp. of America under a \$3,250,000 contract. It's designed to test the possibilities of global-communications satellites—including transoceanic television, telephone, and telegraph transmission. Scheduled to go into an orbit that extends out to 3000 miles, Relay will weigh about 100 lb. The U. S. is co-operating with Great Britain and France in construction of ground stations.

EFFICIENCY OF ROCKET ENGINES, not total thrust, will determine the winner of the competition in space, says S. K. Hoffman, president of Rocketdyne. Calling for more attention to the relative merits of different engine types, Hoffman points out that the nuclear liquid engine promises to provide roughly twice the efficiency of the best liquid-propellant engine, four times that of a solid-fuel engine.

MAJOR SUBSYSTEMS for Dyna-Soar—Air Force's maneuverable space glider—are under development at Thompson Ramo Wooldridge and Westinghouse. TRW will provide the reaction components that will maneuver and stabilize the near-orbital craft outside the atmosphere; Westinghouse is developing generator units. System contractor for the Titanboosted glider is Boeing Airplane Co.



Computing With Air

Use of pneumatic systems for "brains" as well as "muscles" is a new and promising concept. Current research is focused on aerospace applications, where these operating characteristics of sophisticated pneumatic control systems would be extremely desirable:

 Broad operating-temperature range, limited only by the structural integrity of materials used.

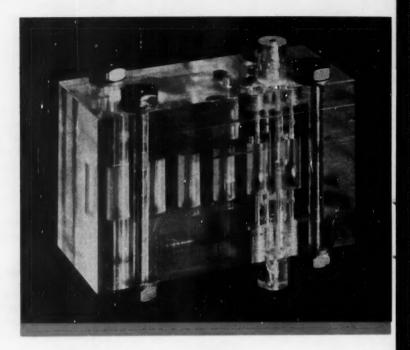
Absolute immunity to ionizing radiation.

Absence of heat-generating elements, permitting very dense packaging of components.

 Ease of information insertion — punched tape, cards, or direct mechanical transducers,

 Simplicity of power-supply requirements.

Development of a fully pneumatic digital computer is already in progress. It centers around a bistable element, or flip-flop, which operates on compressed air or gas. The element can be packaged at 6000 per cu in., or 2000 per cu in. with all interconnections. By extrapolation, this leads to a medium-size digital computer, complete with memory, that would occupy a cube 3 In. on a side.



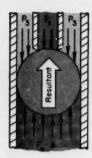
A CCEPTING only limitations imposed by physical laws and current fabrication technology, it is possible to build compact pneumatic devices with response times comparable to many electrical and electronic components.

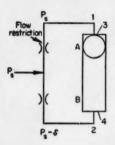
This is the design philosophy behind recent research at General Precision's Kearfott Div., Little Falls, N. J., aimed at the development of a fully pneumatic digital computer. Several other U. S. firms are known to be working along the same lines and, according to Kearfott, reports from Russia indicate that Soviet scientists also recognize the usefulness of pneumatic digital techniques and are engaged in active development in this area.

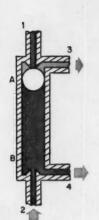
Applications for the pneumatic computer will not go begging. The problem of keeping guidance and control equipment cool in re-entry and boost-glide vehicles, for example, is currently a subject of major concern. The use of gas as an operating medium in navigation and guidance computers would all but solve the problem.

Reasons for selecting the digital approach to a pneumatic computer are the same as for an electronic computer, with one important additional factor: Close control of supply pressure and temperature is ordinarily necessary in pneumatic instrumentation. But since digital circuitry is dependent only on signal timing and duration, not on magnitude, the effects of nonlinearities (inherent in pneumatic elements) pose no serious problems

Basic physical limitations in the design of pneu-







Flip: Ball is stable in "up" position. Low pressure at 3 results from leakage through ball-cylinder clearance.

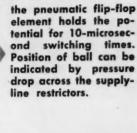


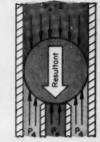
Transition: Momentary blockage of flow at 3 breaks ball-seat seal at A, permits supply pressure to drive ball down.

Packaged 2000 to the cubic inch . . .



Flop: Ball is stable in "down" position. Momentary closure at 4 will drive ball back to stable position A.





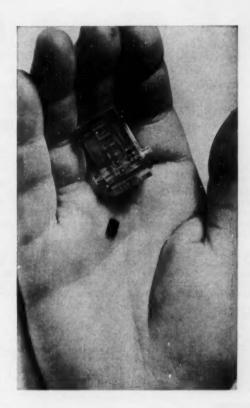
NEWS REPORT

matic computer circuitry are the speed of propagation of a pressure disturbance in the gas (speed of sound), the power density per unit cross section of passage at practical pressures, and the minimum passage and component size compatible with available fabrication techniques.

Within these limitations, says Kearfott, it is feasible to build a pneumatic computer with higher packaging density than comparable electronic computers and with the capability of operating at clock frequencies in the 10 kc to 100-kc range. Present electronic computers work at 10-mc.

Elements of the Kearfott Computer are based on pneumatic instrumentation of the diode and the bistable amplifier; resistance, inductance and capacitance; and use of the principles of the acoustic transmission line,

Diodes, in pneumatic circuitry, are merely orifices operating above critical flow, i.e., with gas flowing through at or above the speed of sound. Under these flow conditions, a pressure disturbance originating upstream of the orifice will propagate downstream through the orifice. On the other hand, a disturbance originating downstream cannot propagate upstream past the orifice since the speed of pressure propagation is the speed of sound and the downstream flow through the orifice is greater than the speed of sound. The ratio of supply to discharge pressure across an orifice for critical flow is roughly 2 to 1 for most gases. Thus, extensive cascading of critical-flow orifices will require very high supply pressures unless



Six pneumatic flip-flops are packaged in the tiny black box (above). Transparent laboratory model contains the same circuitry in larger scale.





TYPE 16 SUBMINIATURE SWITCHES

BETTER PROVED

LONGER LIFE , , , No other subminiature switch can equal the performance and long service life of the Licon Type 16. Only 1/4" thick and 25/32" long, the Licon Type 16 delivers over 20,000,000 operational cycles without mechanical failure. This has been repeatedly test-proved. Quality and uniform dependability make the Type 16 superior to any subminiature switch.

HIGHEST ELECTRICAL RATING ... The tiny Type 16 is rated at 10 Amps, 30 volts d-c inductive. This rating, the highest among subminiatures, is achieved with a unique double-break mechanism that effectively increases electrical performance, and life, as well as capacity. Arc energy and heat dissipation are distributed over two places, mini-

mizing the possibility of contact weld. Double-break design offers multiple circuit possibilities not available in other subminiatures. The Licon Type 16 finds wide acceptance in aircraft and missile applications yet is economically adapted to industrial use. Its rating, dependability and performance equal those of a big switch, but its compact size makes it an excellent choice for use where critical space and weight limitations exist.

VERSATILITY . . . Type 16 switches come in reset, momentary, and specially engineered styles. Leaf spring, lever, roller, plunger or combination actuators are standard. Terminals may be solder, screw, or taper tab and may extend from the bottom, sides, or ends of the switch case. Variations of the Type 16 will be engineered to your specification.



THIS CATALOG IS YOURS on request. It gives dimensional data and engineering "specs" on the Type 16 and the whole broad Licon line. Send for yours today.

X TYPICAL PROVED APPLICATIONS ...

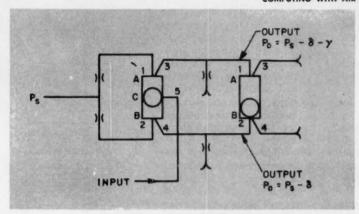
Licon Type 16 subminiature switches are presently in use in missile detonators, sensing devices on automatic machine tools, automatic postal equipment, speed control devices, communication equipment, coin changer equipment, automatic door openers, relay actuation, and a host of airborne controls, including hermetic and environment-free units.

Standard Type 16 Switches and Actuators are available through your local Licon distributor.

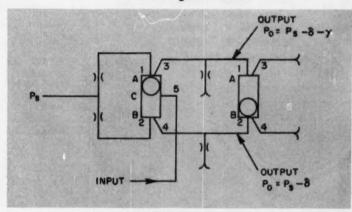
DIVISION OF ILLINOIS TOOL WORKS
6615 W. Irving Park Road, Chicago 34, Illinois

Circle 214 on Page 19

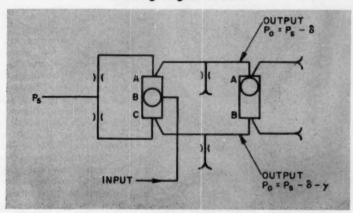




Before Signal Pulse



During Signal Pulse



After Signal Pulse

Pneumatic triode . . .

is used in the circuit of a binary scaler. Tristable element is formed by adding another connection (at the center of the cylinder) to a normal bistable device. When the center connection is open, the ball is driven to the center of the cylinder and remains there regardless of conditions at 3 and 4. When the center outlet is closed, the element behaves as a bistable device. Input is assumed to be a pulse; output is a pressure rise at the indicated location. Each time a pulse is applied to the input, the output element reverses its state.

buffer amplifiers are used.

Pneumatic resistance is an orifice or a capillary . . . instrumentation of simple diode logic circuits involves merely the appropriate interconnection of orifices and capillaries of various sizes.

Pneumatic capacitance is a plenum chamber, and the inductance is a "long" pipe of sufficiently large diameter that viscous losses do not predominate. The differential equations of pneumatic transmission and delay lines are similar to those of rf waveguides.

Unlike some other approaches (e.g., Diamond Ordnance Fuze Laboratory and the Russian) to design of pneumatic bistable amplifiers, the Kearfott device utilizes a moving part (ball). This provides a direct means of converting between electrical and pneumatic signals. Presence of the moving part creates no environmental hazard: Shock of over 50,000 g would be required to disturb a typical Kearfott bistable element operating on 100 psi differential pressure.

Conversion from pneumatic to electrical signals is effected by sensing the position of the ball with a coil, or by capacitor plates or contacts embedded in the walls of the cylinder of the bistable element. Conversion from electrical to pneumatic data is accomplished by forcing shuttle motion magnetically or electrostatically.

Power consumption of the pneumatic computer approximates that of a comparable electronic computer. Small size of the orifices and passages will require cleanliness of the gas supply equivalent to that obtained with three-micron filtering.

The bistable element operates in terms of pressure differentials, and does not, therefore, require overly accurate control of supply pressure, temperature, and leakage within the unit. No absolute seals are required. It is only necessary that certain inequalities in leakage areas have the right sense and approximate magnitude. Typical tolerances and critical dimensions might be:

- Cylinder diameter: 0.020 ± 0.0005 in.
- Moving-element diameter: 0.019

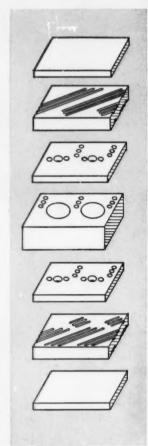
±0.0002 in

• Port and orifice diameters: 0.010 to 0.004 ±0.0002

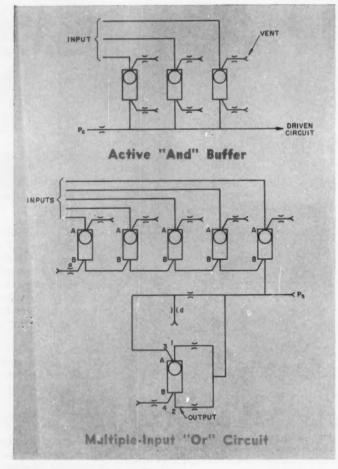
Research at Kearfott thus far has provided analytical and experimental data relating to computer circuits and the performance of individual circuit elements. Work on a complete pneumatic computer, of limited capacity, for evaluation and demonstration is in progress.

Using pneumatic techniques, Kearfott foresees the application of digital computation in completely new ways. For example, an inertial platform incorporating the guidance computer as one of the platform components is a possibility; telemetering instruments incorporating their own data processing are conceivable; and tactical military operations could be provided with extensive portable computing and automatic logic facilities.

Although relatively slow in comparison to electronic computers, the pneumatic machine could take advantage of high packaging density which would permit parallel rather than serial computation. Cost would also favor the pneumatic computer, says Kearfott.



For maximum packaging density and design flexibility, computer circuits and elements are assembled from layers of perforated plates which form the elements themselves and also furnish the means of interconnection. Basic construction consists of a stack of five perforated and two solid plates. The second plates from the outside are matrix plates, which contain herringbone groove patterns on their two faces. Circuit connections are made simply by drilling through the matrix plates at the appropriate intersections of grooves. For moderate temperatures of operation, the matrix plates can be made of any material capable of being fabricated by photoetching or chemical milling. High-temperature operation can be provided by using ceramics or heat-resistant alloys. Typical packaging densities, including power supply and interconnecting circuitry, are 2000 to 4000 bistable elements per cu in.



Typical pneumatic logic circuits . . .

input is assumed to be a pulse; output is a pressure rise at the indicated location. Circuits were developed by Kearfott.



Molysulfide News Digest

CLIMAX MOLYRDENUM COMPANY, a division of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N.Y.

RECENT TEST SHOWS MORE PROOF OF MoS₂'s LOAD-CARRYING ABILITY

New Teflon-MoS₂ Bearing Component Withstands Temperatures Up To 575°F

A new precision ball bearing, which operates at temperatures up to 575°F and needs no conventional lubrication, is now coming off the lines at the Barden Corporation's plant in Danbury, Conn. Trade-named BAR-TEMP, the new bearing utilizes a ball retainer of reinforced Teflon compounded with "Moly" lubricant. Resistance to deformation is much higher than that of pure Teflon*. Also. the material serves as a dry lubricant. As the bearing rotates, microscopic amounts of Molysulfide rub off and are deposited on the raceways. Result: long bearing life at temperatures where conventional lubricants fail.

Successful applications include synchros, fans, motors, blowers, barometic pressure switches, tachometer generators, and other devices operating from 1,000 to 24,000 rpm, at temperatures ranging from -100°F to 575°F.

*T.M. E. I. du Pont de Nemours & Co., Inc.
When writing, refer to CL-105

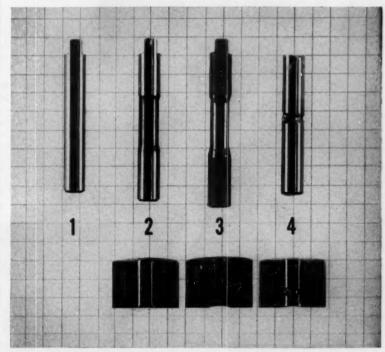
"Moly" GIVES WIRE ROPE 45% MORE BENDING LIFE

That's the forthright verdict of one of the leading wire rope manufacturers, which recently tested its MoS₂-lubricated wire rope against four other leading brands. Fatigue tests and field tests demonstrated the rope's ability to outlast other premium wire ropes in service.

Used as an ingredient in wire drawing compound, Molysulfide creates a micro-shield around each wire. This smooths out minute surface imperfections and prevents the wires from grinding together as the rope flexes. Result: reduction of internal friction—better resistance to fatigue—far longer rope life.

When writing, refer to CL-106

From the German laboratory of Alpha Molykote Corporation comes new proof of Molysulfide's® ability to resist galling and seizing at pressures beyond the yield point of most metals. Previous tests have shown that MoS₂ sustains loads up to 475,000 psi. In this Almen Wieland test, similar to the Falex test, a $\frac{1}{4}$ " pin actually extruded without any surface damage at pressures of 100,000 psi, while similar pins using other lubricants were torn, galled or "frozen" to the point of breakage.



The photo above shows mild steel pins used in Almen Wieland test. No. 1 is unused Control Pin. No. 2 (lubricated with mineral oil and MoS₂) and No. 3 (with MoS₂ bonded coating) were elongated and extruded without weight loss. No. 4 shows typical failure with conventional lubricant. Note that the key sheared off and that pin and block were galled and seized. Surveys of many laboratories indicate that the extrusion

phenomenon exhibited by No. 2 and No. 3 pins has never been produced with any other conventional lubricant.

As a result of Molysulfide's unique pressure-sustaining ability, MoS₂ is widely used as a "break-in" lubricant which prevents abrasion and seizing, permits shorter "break-in" runs, and prevents bearing damage when boundary lubrication occurs.

When writing, refer to CL-107

Potted Hydraulics

Cast-in-Aluminum Servo System
Guides an Army Missile

C. H. MATSON and A. STEPHENSON

The Martin Co. Orlando, Fla.

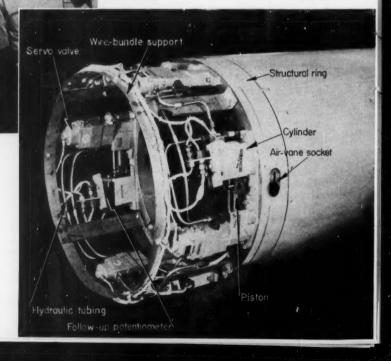
COMPONENT potting has been one of the true "breakthroughs" in electronic design. It provides an easy and reliable method of protecting delicate circuitry against shock, vibration, and a host of other environmental extremes.

The state-of-the-art in hydraulic packaging can be roughly compared to that in electronics before potting. Components are either grouped and mounted on what might be called a chassis, or are attached

Before: Four control actuators, with related components, were hung (in the traditional manner) on a forged-aluminum ring. Attached by rivets to the outer skin of the missile, the ring also supported the four missile-control surfaces. Exposed plumbing was a likely candidate for damage by shock, vibration, and other environmental hazards. Misalignment of close-tolerance cylinders, for example, became a problem.

Army's Lacrosse—a fin-stabilized artillery-type guided missile used for close tactical support of ground troops. Solid-fuel powered, it has a range of 20 nautical miles, is fired from its own mobile launcher. The weapon is 19 ft long, weighs 2300 lb. Nose-fin span is 9 ft.

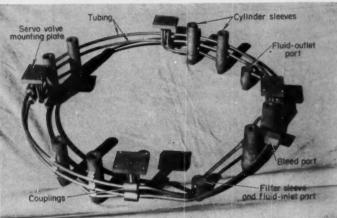
ARC ARTY



Circle 12-2 on Page 19 for extra copy.



Brazed core assembly . . .



to the nearest convenient appurtenance.

Designers at Martin Co., Orlando, recently enhanced the performance (and production) of the Army's Lacrosse missile by applying the potting technique to hydraulic circuitry in the missile's flight-control system (four hydraulic actuators control the guidance fins).

In the Martin technique, hydraulic lines and components are first brazed into circuitry, and the assembly then forms the "core" around which aluminum is poured. A ceramic coating, applied to the stainless-steel core assembly, solved an aluminum-to-steel bonding problem. Completed castings are inspected radiographically.

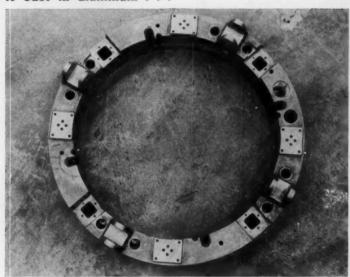
End result of the hydraulic-potting project can be summarized by these advantages over the previous assembly:

- Exposed plumbing and connections are eliminated.
- Assembly and checkout have been made bench operations.
- Mass of the casting serves as a heat sink for hydraulic fluid.
- Leakage and contamination are reduced.
- Buried parts are immune to exposure and damage, and are protected to a high degree from shock and vibration.

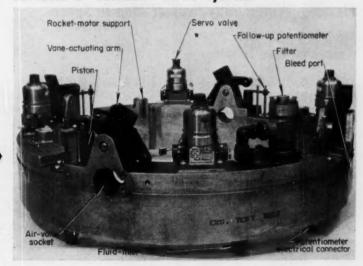
The new technique also resulted in a 20 per cent reduction in weight and cost of the actuators.

After: Actuator cylinders and lines, made of stainless steel, are assembled by brazing to form the core of an aluminum casting. Major part of the plumbing (some 26 components) thus becomes an integral part of a structural ring which is bolted to the missile proper. Cylinders have been reoriented from a lateral axis to a fore-and-aft axis; rocker arm with roller contacts spans the pistons and attaches to the fin fitting.

is cast in aluminum . . .



to form a "unitized" servo system



Putting the Army Back on its Feet

Professor Shigley's Walking Machine



Sixteen legs and a maze of linkages provide a radical means of locomotion for this proposed Army vehicle. Walking mechanism (below) is one of several that are being evaluated by Army and U-M researchers.

ANN ARBOR, MICH.—Invention of the wheel has probably done as much to advance warfare as the airplane or the atom bomb. And military commanders remain constantly alert to new and more efficient vehicles for moving ground troops.

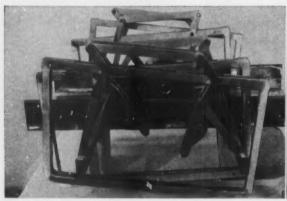
Object of one of the latest projects aimed at increasing infantry mobility appears at first glance to be a big step backward. It's a prime mover that has feet in place of wheels. Design of the vehicle is being directed by Professor Joseph E. Shigley, University of Michigan, for Army's Land Locomotion Laboratory, Ordnance Tank-Automotive Command, Detroit. The "walker" reportedly could stride over plowed

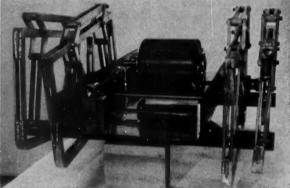
fields at 30 mph, and on certain types of terrain would be superior to wheeled or tracked vehicles.

As Professor Shigley describes it, his perambulating machine would have 16 legs—four at each corner. While one leg was actually making a stride, the second would be lifting off the ground to return for another stride, a third would be returning, and the fourth lowering for its step. Motion would be controlled by a hydraulic mechanism driven by a constant-speed engine. Length of the legs could be made to suit the particular vehicle.

"There's a good possibility we could find a way to make the machine walk in a crouch," says Prof. Shigley. "This way it could sense different levels underfoot and make possible smoother rides over rough terrain at higher speeds."

Various technical problems are admittedly troubling the designer. Foot and shoe design (shape, dimensions, method of attachment), leg linkage, and suspension are knotty problems that require solution. Given time for analysis, however, Prof. Shigley is confident that these details can be worked out satisfactorily.





Flexible 'Water' May Protect Man in Space

Wet Insulation Boils Away Heat

Dallas, Tex.—A flexible blanket of water which can protect man and equipment against searing re-entry temperatures may solve one of the toughest problems in current space-vehicle research.

Developed by Chance Vought Corp., Dallas, Tex., the new material is composed of more than 90 per cent water, but has the handling characteristics of a solid. Vought calls the material Thermosorb.

Placed between the inner and outer walls of a space craft, Thermo-

sorb could hold the inside temperature of the vehicle well within the limits of human tolerance while the temperature of the outside skin skyrocketed to 4000 F.

The new material already has been used successfully in rockets to protect instruments and components located in compartments adjacent to rocket-motor nozzles. Temperatures on the outer wall of the nozzles reached 2200 F, but were held to less than 150 F on the cool side of the Thermosorb.

The Vought-invented material resembles a cross between a piece of wet felt and a fine-grained cellulose sponge. It retains water with such tenacity that specimens have been subjected to 16 g in a centrifuge without the water separating. Just what holds the water together has not been disclosed. Samples also have been subjected to violent vibration (20 to 2000 cps), high noise levels, and to temperatures as low as $-65 \, \mathrm{F}$.

Although versatility is one of the material's more important characteristics (Thermosorb can be fabricated in almost any shape and size), Vought scientists regard its light weight, durability, and reliability as equally important advantages.



Rolls can take a beating when they are centrifugally cast by Shenango

Not only steel mill run-out table rolls as illustrated here, but glass making rolls, paper mill rolls, aluminum forming rolls and many others stand up longer and need to be redressed less frequently if they are centrifugally cast by Shenango. Ferrous or non-ferrous casting by spinning means cleaner, denser grain structure with no blow-holes or inclusions. And because Shenango operates one of the best staffed and most extensive modern centrifugal foundries and machine shops in the country, your largest orders will be filled with accuracy and dispatch.

CENTRIFUGAL CASTING DIVISION

the Shenango

FURNACE COMPANY

DOVER, OHIO

THIS IS SHENANGO!





iron ore

pig iron and coke





ingot molds and stools

contribunal continue

lake transportation

Copper, Tin, Lead, Zinc Bronzes - Aluminum and Manganese Bronzes - Monel Metal - Ni-Resist - Meehanite Metal - Ductile Iron

Circle 216 on Page 19

The new Skyknight, to be introduced by Cessna Aircraft Co. in August, flies high, fast, and handsome. Designed for long-distance travel over weather (service ceiling is 27,200 ft), it is powered by twin Continental fuel-injection engines. Exhaust-driven turbo superchargers maintain full 260 hp at altitudes up to 16,000 ft, provide a single-engine ceiling of 17,400 ft. Interior of the plane provides "stretch-out,

move-around" room. The five passengers' seats move forward and back and recline individually. Maximum speed of the Skyknight is 265 mph; cruising speed at 10,000 ft is 223 mph. Price: \$67,500.



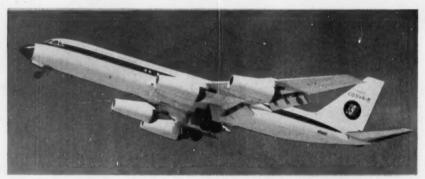




To find out what goes on under the ice of a frozen lake, Prof. Donald Livermore of the University of Wisconsin and several graduate students designed this battery-powered underwater tractor. An air-tight aluminum box, it floats, pressing two spiked wheels and a sled runner (for steering) against the underside of the ice. Sound waves control the tractor's movements, and tracking is by means of a small radioactive source and a scintillation counter. Instruments are pulled behind the tractor at ½ to 2 mph for four hours on one battery charge.

Transonic transport, the Convair 990 jet has flown at Mach 0.97, a feat which allows it to claim the title of fastest passenger transport in the world. The 990 flew at an altitude of 22,500 ft and attained a true air speed of 675 mph. The plane was being test-flown to prove out a change in positioning of the outboard engine pods, which were moved aft to shorten the period of vibration that could be set up by

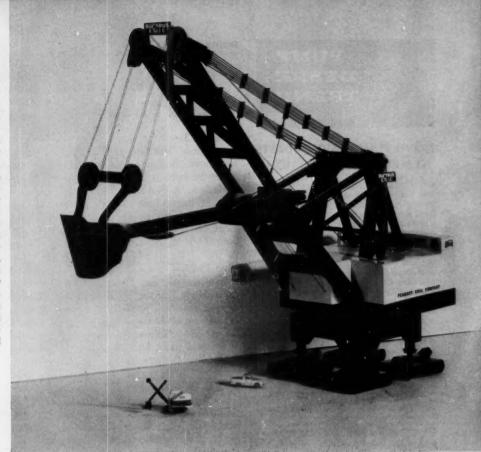
mishandling of flight controls. The 990 will be certified for Mach 0.91 flight when it is introduced on commercial airlines the end of the year.



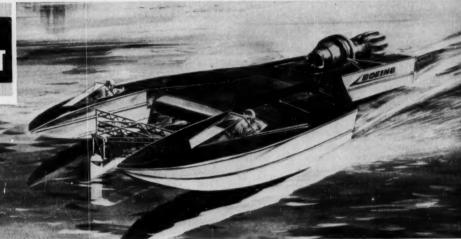
Radio-size television, one of the "Sets of the Seventies" proposed by Radio Corp. of America, depends upon successful development of a very thin picture tube. So far, RCA has made an experimental tube 2 in. deep for black and white, but picture quality is not good. All 1970 TV sets will receive color broadcasts, according to RCA. This little model would also have stereophonic radio and would be clock-operated.



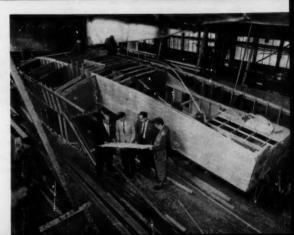
One of a pair of mechanical mammoths being built by Bucyrus-Erie Co. for the Peabody Coal Co., a 115-yd excavator will weigh 15,000 tons and will stand 210 ft, or about 20 stories, high. In 50 seconds, the dipper will pick up 170 tons of earth, dump it more than 400 ft away, and swing back for the next gulp. One man, in a five-storyhigh, air-conditioned cab, will control operations with two hand levers and two foot pedals. To be used in uncovering deeply buried bituminous coal seams, the excavator is to be erected at the Kentucky mine site, after 250 railroad cars bring components from Bucyrus-Erie's South Milwaukee Works. The toy-size machines in this builtto-scale group are a 1-cu yd shovel and a pickup truck.



PICTURE REPORT



Jet-propelled laboratory provides a level and stable platform for testing marine-vehicle designs. A model under test is mounted between the "claws" of the lobster-shaped hull, and the boat accelerates to 100 knots in a one-minute run. One of the twin cockpits carries the boat operator; the other, a test observer. The engine, an Allison J-33, develops 4600-lb thrust and operates just as it would in an airplane. No underwater propeller is used. Built for Boeing Airplane Co., by Philip F. Spaulding & Associates, the boat supplements the tow-tank method (towing models in a water tank at high speeds) of testing hydrodynamic shapes.



TRENDS

NOVEL PUMP DESIGN ADAPTS TO MANY CONFIGURATIONS

The reliability-proved Gerotor pump has long been recognized as a space-saving unit because of its extreme flexibility of design. That's because Gerotor pump capacity is a function of diameter, thickness, number of teeth and rpm of the two moving parts. These variables can be matched to just about any space restriction and capacity requirement. Now, you can save even more space by building three simple pump components integrally into your mechanisms with no more trouble than providing for an anti-friction bearing.



Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing of frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

▶ A wide variety of sizes is available covering capacities up to 100 gpm and

1,000 psi. Unlike complete pumps, the inserts are extremely flexible in adapting to various mechanism geometries.



The resulting pump is a self-priming, positive-displacement, light weight

placement, DISCHARGE CYCLE lightweight, valveless mechanism. It is long-wearing, and handles impurities in the fluid well. It can be made to pump in the same direction regardless of direction of rotation. It provides a relatively pulseless flow: volumetric and mechanical efficiencies are high; it is balanced and quiet in operation.

A unique combination of adaptability and reliability also accounts for the growing popularity of integrally designed pumps built with these Nichols packaged components. A wide range of applications includes circulating or lubricating systems, scavenging oil away from pumps, powering low-pressure hydraulic systems, replenishing other pumps, hydraulic brakes, etc.

► Technical data is available. Write:

W. H. NICHOLS CO.

Makers of Zenith Metering Pumps and the Nichols Milling Machine "the miller that uses its head".

48 WOERD AVE., WALTHAM 54, MASS.
Circle 217 on Page 19

Meetings and Shows

June 18-23-

American Institute of Electrical Engineers. Summer General Meeting to be held at Cornell University, Ithaca, N. Y. Annual Meeting of of AIEE begins June 19. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

June 19-21-

Institute of the Aerospace Sciences. Heat Transfer and Fluid Mechanics Institute, to be held at the University of Southern California, Los Angeles. Additional information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

June 25-28-

American Society of Agricultural Engineers. Annual Meeting to be held at Iowa State University, Ames, Iowa. Additional information is available from society headquarters, 420 Main St., St. Joseph, Mich.

June 25-30-

American Society for Testing Materials. Annual Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from ASTM, 1916 Race St., Philadelphia 3, Pa.

June 26-27-

Fifth Annual Conference on Vacuum Metallurgy, sponsored by American Vacuum Society and New York University, to be held at University Heights campus of N. Y. U. Further information can be obtained from the society, P. O. Box 1282, Boston 9, Mass.

June 26-28-

Institute of Radio Engineers. National Convention on Military Electronics to be held at the Shoreham Hotel, Washington, D. C. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

June 26-28-

American Society of Heating, Refrigerating and Air - Conditioning Engineers. Annual Meeting to be held at the Denver Hilton Hotel, Denver. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

June 26-30-

American Institute of Electrical Engineers. Aerospace Transportation Conference to be held at the Benjamin Franklin Hotel, Philadelphia. Additional information is available from AIEE, 33 W. 39th St., New York 18, N. Y.

Iune 28-30-

Second Joint Automatic Control Conference to be held at the University of Colorado, Boulder, Colo. Sponsors are Instrument Society of America, American Institute of Electrical Engineers, American Society of Mechanical Engineers, Institute of Radio Engineers, and American Institute of Chemical Engineers. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

July 4-7-

National Society of Professional Engineers. Annual Meeting to be held at the Olympic Hotel, Seattle, Wash. Additional information can be obtained from NSPE, 2029 K St. N.W., Washington 6, D. C.

Aug. 14-17-

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Sheraton Hotel, Portland, Ore. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

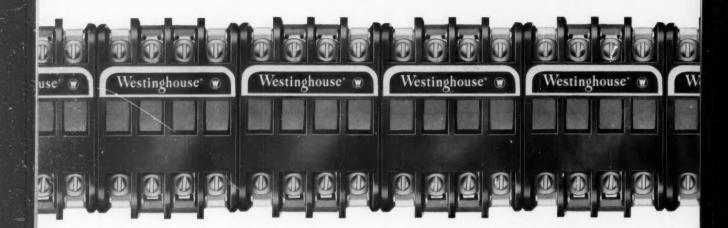
Aug. 22-25-

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon headquarters, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Aug. 28-Sept. 1-

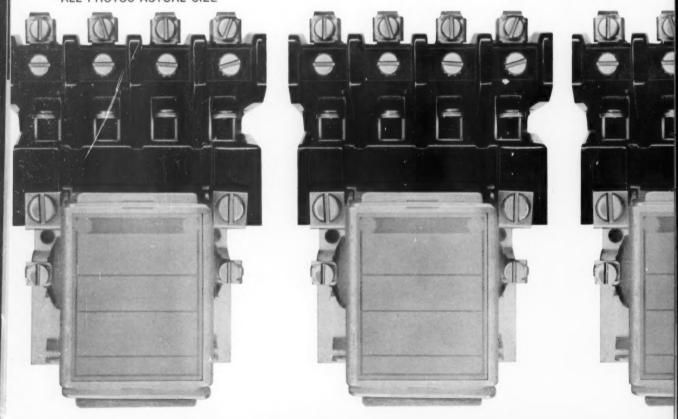
International Heat Transfer Conference to be held at the University of Colorado, Boulder, Colo. Sponsors are American Society of Mechanical Engineers and American Institute of Chemical Engineers; also participating are American Society.

New Westinghouse BF relay shrinks machine control relay panel space 33% to 78%



See for yourself how many new Westinghouse BF relays

ALL PHOTOS ACTUAL SIZE



General characteristics of the Westinghouse BF relay

Dimensions '

Without base plate: 111/16" x 23/8 With base plate: 111/16" x 31/8

Operating time

Pickup: 12.5 to 18.0 millisecords Dropout: 6.25 to 12.5 millisecords

Relay can be operated manually to test circuits.

4 and 8 pole frames in any combination or normally open and normally closed contacts with a maximum of 4 normally closed.

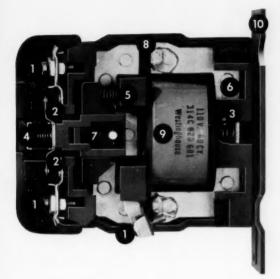
Contact rating – 6 amps. 300 volts AC, 60 amperes inrush.

Relay can be mounted in any position on a vertical surface without changing operational characteristics.

The Westinghouse BF relay provides these features

- up to 78% less mounting space required
- front accessible
- can be butted without extra space for wiring
- quick coil and contact changes when needed
- low operating temperature
- lower installed cost
- long service life
- magnet and armature have specially hardened pole faces
- shorter operating stroke
- · lightweight operating parts
- silver alloy contacts have built-in wiping action for prolonged circuit continuity

How the new Westinghouse design assures reliability and durability



EASILY WIRED

 All connections are wired from the front with pressure clamp terminals.

OUTSTANDING CIRCUIT CONTINUITY

- Proper contact wipe is built-in for long life of the silver alloy contacts and for positive circuit continuity.
- Contact bounce is minimized by unique magnet suspension that eliminates shock and jar.
- Automatic, positive alignment of crossarm insures simultaneous contact of all poles.

POSITIVE OPERATION

 Stainless steel kickout springs permit any mounting position on a vertical surface independent of gravity.

LONG MECHANICAL LIFE

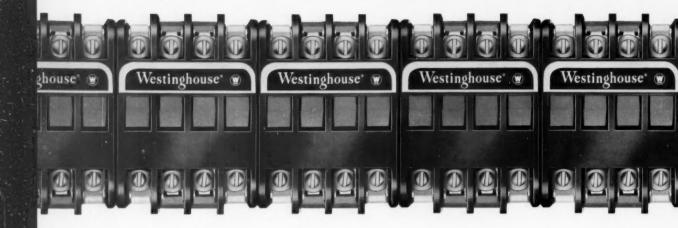
- In addition to preventing contact bounce, the magnet suspension cushions the contact between armature and magnet, protecting entire unit from shock.
- Low mass and short stroke, possible only with a small relay, save wear on every moving part
- 8. Pole faces are surface hardened to maintain desired air gap.

MINIMUM POWER LOSS

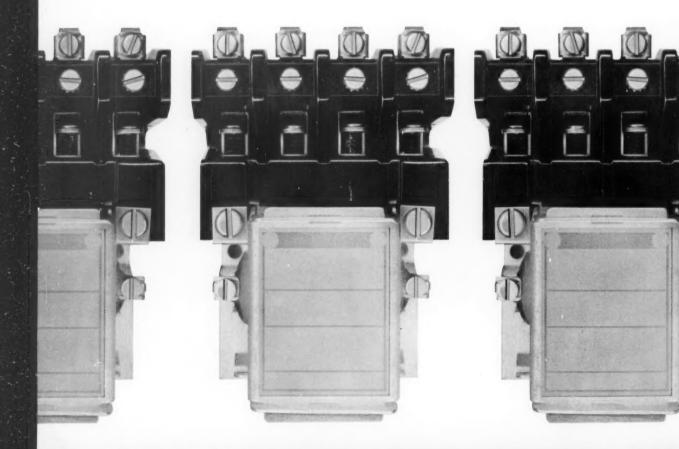
 Closed gap coil loss is only 3 watts for low coil operating temperature. Open coil burden 70 volt amps; closed, 11 volt amps.

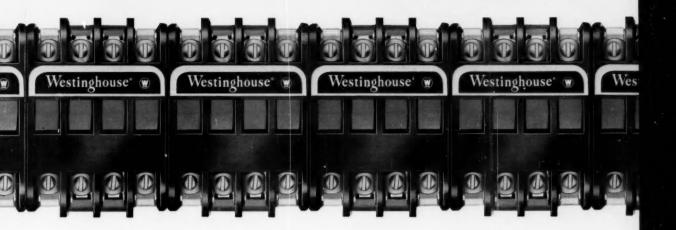
EASE OF MOUNTING

 Steel base has keyhole slots for rapid installation, extends only into wiring area to avoid space waste, and may be removed if desired.



can fit in the same space as 7 conventional relays—this i

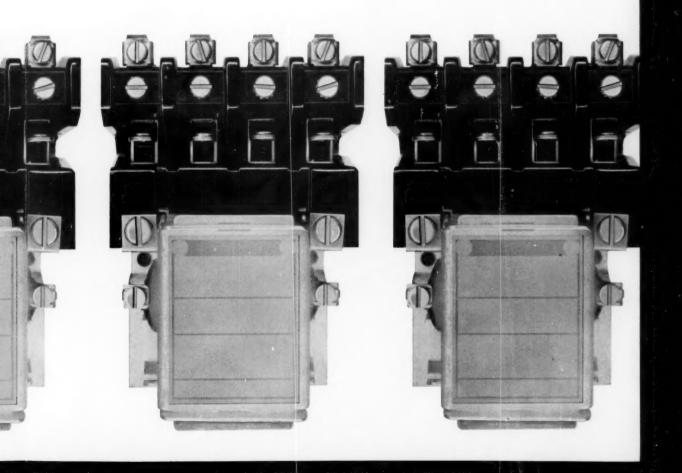




s is how control panels can be reduced as much as 78%

You can be sure . . . if it's Westinghouse (\varphi)





BF relay contact information

			8 POLE						
CONTACT ARRANGEMENT		8 N.O. 0 N.C.	7 N.O. 1 N.C.	6 N.O. 2 N.C.	5 N.O. 3 N.C.	4 N.O. 4 N.C.			
	REAR	0 0 0 0	0 0 0	0000 11:	0000	0000			
	FRONT	00110	0110	9 9 9 9	0770	9999			

6 POLE										
6 N.O. 0 N.C.	5 N.O. 1 N.C.	4 N.O. 2 N.C.	3 N.O. 3 N.C.	2 N.O. 4 N.C.						
9999	9999	0000	0 7							
0-11-0	0 1 1 0	0110	9110	9119						

CONTACT ARRANGEMENT

2	2 POLE			3 P	OLE				4 POL	E	
2 N O. 0 N C.	1 N.O.	0 N O. 2 N C.	3 N.O. 0 N.C.	2 N.O. 1 N.C.	1 N.O. 2 N.C.	3 N.C.	4 N.O. 0 N.C.	3 N.O. 1 N.C.	2 N.O. 2 N.C.	1 N.O. 3 N.C.	0 N.O 4 N.C
100	001	0 0 1 1 1 1 0 0 1	9913	0.11-0	01/0	0740	9999	9940	0010	0110	0 # 0

Westinghouse engineers have helped solve the design problem caused by the enlarged control panels needed to operate highly complex automated machine tools. The new Westinghouse BF Control Relay . . . although compact in size . . . has a rated full load current of 6 amperes at 300 volts AC. In new or modernized facilities, it assures more productive capacity per square foot from every automated machine tool.

Type BF-60 cycles

number of	conf	tacts	open type
poles	normally open	normally closed	catalog number
	2	0	BF20A
2	1	1	BF11A
	0	2	BF02A
	3	0	BF30A
3	2	1	BF21A
	1	2	BF12A
	0	3	BF03A
	4	0	BF40A
	3	1	BF31A
4	2	2	BF22A
	1	3	BF13A
	0	4	BF04A
	6	0	BF60A
	5	1	BF51A
6	4	2	BF42A
	3	3	BF33A
	2	4	BF24A
	8	0	BF80A
	7	1	BF71A
8	6	2	BF62A
	5	3	BF53A
	4	4	BF44A

Ordering information

BF Relays are available direct through your nearest Westinghouse representative. When ordering be sure to specify the total number of poles desired, including the number of poles open and the number closed. Also specify coil control voltage and cycles. The chart at the left shows some of the most widely used relays with 110-volt, 60-cycle control voltage. Consult your Westinghouse representative about other BF Relays which are available. Or write Westinghouse Standard Control Division, Beaver, Pa.

You can be sure . . . if it's Westinghouse



(Continued from Page 36)

ciety of Refrigerating and Air Conditioning Engineers, Chemical Institute of Canada, Engineering Institute of Canada, Institute of the Aerospace Sciences, Society of Automotive Engineers Inc., and the University of Colorado. Papers will be presented by engineers from 13 countries. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Sept. 5-8-

Association for Computing Machinery. 16th National Conference and First International Data Processing Exhibit to be held at the Statler-Hilton Hotel, Los Angeles. Further information is available from Benjamin F. Handy Jr., General Chairman, Litton Systems, 5500 Canoga Ave., Woodland Hills, Calif.

Short Courses and Symposia

June 18-30-

Seminar on Underwater Missile Engineering, to be held at the Pennsylvania State University, will deal with underwater acoustics, transducers, homing systems, control systems, hydrodynamics, flow noise, propulsion, and noise reduction. Additional information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

June 19-21-

Heat Transfer and Fluid Mechanics Institute, sponsored by American Society of Mechanical Engineers, to be held at the University of Southern California, Los Angeles. Additional information is available from ASME, 29 W. 39th St., New York 18, N. Y.

June 25-30-

R & D Management Development Seminar, to be held at the Pennsylvania State University, will cover trends in R & D management, work relationships and decision-making, building an effective organization at the technical level, management role of the research supervisor, leadership patterns for technical and scientific supervision, executive action, foundations of a management development program, and evaluating staff and supervisory potential. Further information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

June 26-30-

Summer Program on the Science of Adhesion to be held at Massachusetts Institute of Technology, will include discussion of solid surfaces, application of adhesives, wetting, tackiness, types of adhesives, stresses in adhesive joints, nondestructive and destructive testing,



"Mr. Wilson, I think you should know that half your engineers are asleep at their desks . . . Mr. Wilson?"

adhesion in reinforced plastics, and theory of adhesive joints. Additional information is available from Director of the Summer Session, M.I.T., Cambridge 39, Mass.

July 10-14-

Institute on Technical and Industrial Communications, to be held at Colorado State University, will provide counseling and basic and advanced instruction in technical writing and related industrial communication. A Problem Clinc will be held each afternoon. Further information is available from Director, Institute on Technical and Industrial Communications, Colorado State University, Fort Collins, Colo.

(Please turn to Page 46)

FRENSION DE

... means alloy flexibility

Through investment casting, your metal parts can be made in a wide range of ferrous, nonferrous and super alloys. Results — better performance...longer life...lower costs!

This part for can making machinery now cast in a non-machinable alloy offers a very high degree of resistance to wear and corrosion. Results — costly parts replacement problems ended.

Better alloys often cost no more than the "inexpensive" ones when your part is an investment casting. What counts is castability, not machinability.

com a Info

complete technical and facilities information.

HITCHINER
Milford 2, New Hampshire

Circle 219 on Page 19

WITH MAN IN SPACE



McDONNELL AIRCRAFT CORPORATION, Lambert Field, St. Louis, Missouri, is prime contractor for the Mercury Capsule, under the direction of the National Aeronautics and Space Administration. Photo shows capsule similar to the FREEDOM VIII used in successful launch.

The time: May 5, 1961, 10:34 AM, EDT. The man: Commander Alan B. Shepard, Jr., USN, Astronaut. The event: launching of the Mercury Capsule with man on a down range step into space. The metal: titanium for a combination of strength and lightweight in the vehicle's double wall stringer construction.

A major supplier of commercially pure AMS4901 titanium in the Mercury Project, Republic Steel is the nation's *largest* producer of high-performance metals. Republic is a new source of a complete line of precipitation hardenable stainless steels... the only source of continuous rolled stainless sheet up to 60" wide... the largest producer of stainless and alloy steels, and steels for cold extrusion.

To meet the challenge of space, Republic Steel is looking deep into the microstructure of steel... pulling facts from the heart of steel... aiming at fantastic new steels with tensile strengths even beyond 400,000 psi.

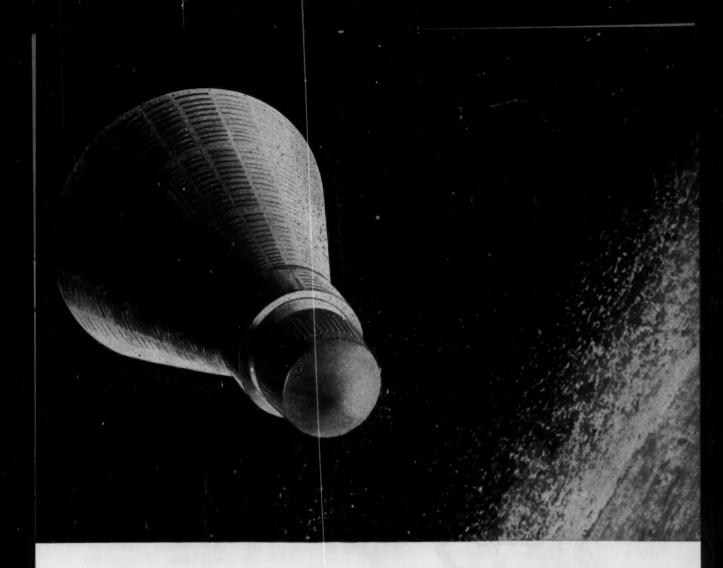
Republic's 3-Dimensional metallurgical teams—composed of mill, field, and laboratory metallurgists—help you select, apply, and process the most economical metals capable of meeting requirements. This is a confidential, obligation-free service. For additional information, contact your Republic representative or mail the coupon on the opposite page.

Circle 220 on Page 19

DESIGN ENGINEERS: Mail the coupon for a copy of Republic's new booklet, Products For The Design Engineer.
Contains a useful Stainless Steel Selector Chart, and information on Republic High Strength Steels, Titanium, Electrical Steels, Vacuum Arc Melted Steels, and other high performance metals.

Circle 221 on Page 19





VACUUM ARC MELTED METALS . . .

Processed into billets, bars, plates and sheets, strip, or wire, Republic Vacuum Arc Melted Metals are produced in 4,000- to 20,000pound ingots. The consumable electrode vacuum-melting process improves tensile strength, ductility, fatigue life, and perform-ance at high and low temperatures. Precise control reduces nonmetallic inclusions and harmful gases. Republic helps you select the vacuummelted metal best suited to requirements: constructional alloy steel, high strength alloy steel, bearing steel, stainless steel, super alloy steel, titanium, or special carbon steel. Circle 222 on Page 19

REPUBLIC PH STAINLESS STEELS . . .

Republic PH 15-7 MO* for missiles and aircraft offers high ultimate tensile strength with excellent mechanical properties to 1000°F. Republic 17-4 PH* for shafts, gears, pins, and other components requires only a one-hour heat treatment at 900°F to develop its full strength (ultimate tensile strength to 200,000 psi). Republic 17-7 PH* for pressure tanks, bellows, springs, and other applications provides better corrosion resistance than the hardenable grades of chromium stainless. Send for PH Stainless Steel Booklet.

*Licensed under Pat. Nos. 2482096, 2505763 and Trade Mark of Licensor. Circle 223 on Page 19



REPUBLIC

REPUBLIC HAS THE FEEL FOR MODERN STEEL

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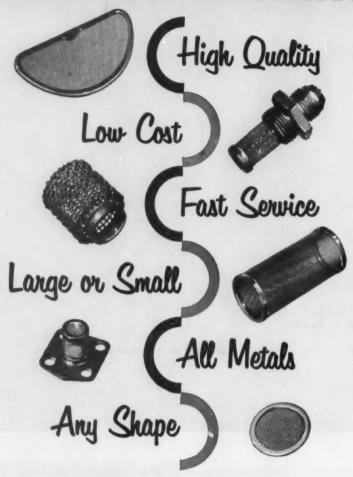
Please send PRODUCTS FOR THE DESIGN ENGINEER Booklet

| Would also like more information on:
| Republic Titanium
| Vacuum Arc Melted Metals
| Republic PH Stainless Steels

Title. Company_

City_ Zone_State

WIRE CLOTH PARTS



Wire cloth parts fabricated to your order are a Newark specialty. One division of our company is fully equipped and staffed to to manufacture any part you need with a wire cloth insert.

We also offer an engineering service to assist you in design or redesign of your parts.

Ours is a "one-stop" service . . . we deliver complete parts guaranteed to meet your specifications. Send for our Fabricated Parts Catalog.

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Representatives in all principal industrial areas

(Continued from Page 43)

July 10-14; July 17-21-

Two Programs on Strain Gage Techniques will cover both theoretical and practical considerations. The first program will consist of lectures supplemented by illustrative demonstrations. Topics include basic theory of foil and wire-resistance strain gages, details of gage characteristics, mechanical and electrical aspects of the gage system, dynamic and static strain measurements, and high-temperature strain gages and their installation. The second program will provide experience in handling strain gages and allied equipment. Exercises will include installation, dynamic strain measurements at high and low frequency, strain rosette analysis, and direct measurement of force, torque, bending, and shear. Further information is available from Director of the Summer Session, M.I.T., Cambridge 39, Mass.

July 24-28-

Advanced Topics on Solid-State Masers summer conference, to be held at the University of Michigan, will cover recent developments in the field. Topics include cross relaxation, optical pumping in solids, optical and infrared masers, advanced technology of cavity and traveling wave masers, and applications of maser systems. Further information is available from Engineering Summer Conferences, 126 West Engineering Bldg., University of Michigan, Ann Arbor, Mich.

July 24-28-

Course on Applications of Stress Analysis to Design and Metallurgy, to be presented at the University of Michigan, will cover principles and methods for applying stress analysis to problems of engineering design, material specification, laboratory testing, and field failures. Topics will include static, fatigue, and impact loading; notch sensitivity and stress concentration; size effect; cumulative damage, understressing and overstressing; problems of life expectancy; statistical interpretation of stress and fatigue data. Additional information can be obtained Engineering Summer Conferences, 126 West Engineering Bldg., University of Michigan, Ann Arbor, Mich.



FLEXONICS CAN HELP YOU. If you are confronted with a problem involving absorbing, compensating, transmitting, or converting energy or force, your answer may well be a bellows. A good source of counsel is the Flexonics Application Engineering Staff. These men are experienced in all areas of bellows application

from the simple sensing device of the domestic range to highly intricate and delicate fluid metering controls for missile engines. Flexonics bellows can be furnished in a broad range of metals. You are invited to submit your problem for analysis — without obligation.

8-540

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DIVISION OF CALUMET & HECLA, INC.

FLEXIBLE METAL and SYNTHETIC HOSE EXPANSION JOINTS BELLOWS • SPECIAL TUBULAR ASSEMBLIES

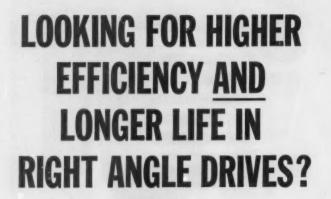


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Flexonics 350 East Devon Bartlett, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.

LEXON BELLOWS



Then take a closer look at Philadelphia Spiral Bevel Reducers. They'll give you an efficiency advantage of 5 to 50% over other types of right angle drives . . . depending upon ratios.

HIGH EFFICIENCY. With efficiencies of 95 to 98%, spiral bevel reducers will lower your power costs . . . reduce the cost of prime movers.

HEAVY DUTY. The bearings and shafting in Philadelphia Spiral Bevel Reducers are designed for 185% overload. Spiral Bevel Gears and Pinions are hardened after they are cut, then lapped to a mirror finish. Helical gearing in multiple reduction units is precision hobbed and shaved from through-hardened alloy steel. Result: greater load carrying capacity, longer life.

COOLER RUNNING. Compared to other types of right angle drives, Philadelphia Spiral Bevel Reducers run cooler. Separate cooling systems are not needed for most applications.

COMPLETE LINE. Philadelphia Gear offers the most comprehensive line of Spiral Bevel Reducers available — or we can build specially engineered units to meet any special requirement. Ratios from

1:1 to 238:1. Single, double or triple reductions in either vertical or horizontal types. Catalog SB-60 gives full selection data. Write on your company letterhead for your copy.

philadelphia qear drives

PHILADELPHIA GEAR CORPORATION King of Prussia (Suburban Philadelphia), Pennsylvania



Now Available...



QUENCHED AND TEMPERED STRUCTURAL SHAPES

in such grades as "T-1", "T-1" type A, 9% Nickel and HY-80 **Constructional Alloy and Armor Steels**

Announcing another industry "first" for United States Steel-USS Quenched and Tempered Alloy and Armor Steel Structural Shapes are now commercially available for the first time anywhere, in the types and sizes shown in the accompanying tables. The more commonly used sizes of American Standard Beams, Channels, Equal Angles and Unequal Angles will be produced in these USS Steels: "T-1", "T-1" type A, 9% Nickel, HY-80 and certain other alloy grades that provide desirable mechanical properties after quenching and tempering. Later, other sizes and shapes will be added according to demand.

These quenched and tempered alloy and

armor steel structural shapes (see table below) can simplify design and result in substantial weight savings, increased structural strength and reduced shipping and handling costs. For a free folder about any of these steels or their structural shapes, contact your local USS representative or write to United States Steel, Room 6317. 525 William Penn Place, Pittsburgh 30, Pa. USS and "T-1" are registered trademarks

United States Steel Corporation - Columbia-Geneva Steel Division . Tennessee Coal & Iron Division . United States Steel Supply Division • United States Steel Export Company

Availability Quenched and Tempered standard structural shapes are available in the following shapes and sizes:

Beams: 6" to 12" inclusive

American Standard Sections and Foot Weights*

Channels: 6" to 15" inclusive

American Standard Sections and Foot Weights*

Equal Angles: 3" to 8" inclusive

Standard Sections*

Unequal Angles: 31/2" x 3" to 8" x 6" inclusive Maximum Length 40' for all sections

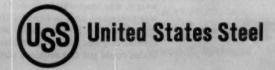
Standard Sections*

*See our booklet, "USS Shapes & Plates," ABUCO-27001

Mechanical Properties of Quenched and Tempered Alloy and Armor Steel Structural Shapes

	Yield Strength,	Tensile	Elong, in 2*,	Reduction	Longitudinal Charpy Impact (when specified)		
	psi	Strength, psi	% min.	of Area, % min.	Keyhole	V-notch	
"T-1" Steel 2½" and Under	100,000 (min.)	115,000/140,000	18	55⊚	15 ftlbs. ⊜ -50F	30 ftlbs. @ +10F	
"T-1" type A 1" and Under	100,000 (min.)	115,000/140,000	193	45⊛	15 ftlbs. @ -50F	-	
Grade A 9% Nickel	60,000 min.	90,000 min.	22% min.				
Grade B 9% Nickel	65,000 min.	95,000 min.	20% min.		15 ftlbs. ● -320F	20 ftlbs. @ -320F	
HY-80 ¼"-2" Incl.	80,000/100,000③	10000	190		-	70 ftlbs. @ 20F	

^{134&}quot; and under-45% min.



[⊙]½° and over, yield strength range is 80/95,000 psi ⊙¾° to 1º inclusive, elongation 16% min. ⊙½° to 2º inclusive, elongation 20% min. ⊙¾° to 1º inclusive, 55% min.



GLX-V COLUMBIUM-TREATED CARBON STEEL CUTS DEAD WEIGHT 10% IN NEW



Bringing important new economies to rail shipment of automobiles, this new tri-level auto carrier holds twelve standard cars or mixed loads of 14 standards and compacts. Capacity is increased up to 75%. A unique system of hydraulically positioning the vehicles on three levels gives a clearance of only 16 feet 8 inches, permits use in areas formerly limited to bi-level unit operation because of clearance requirements. ★ Key feature of the Multi-Car Carrier is the movable decks on which the cars ride. Made of GLX-W columbium-treated steel, the decks are raised and lowered by built-in hydraulic lifts, actuated by a portable power unit. Here light weight was essential, in order to reduce the operating power requirements. Yet great strength was necessary, too, to support the payload. Finally, design of the decks called for eight bends in each section. So formability was also a must. ◆ GLX-W met and exceeded all these requirements. It gives 50-100% greater strength than mild carbon steel, so builder Whitehead and Kales could get the required strength with less weight. Deck operating units need less power,

Great Lakes Steel is a Division of



Multi-Car Carrier built by Whitehead and Kales for Multi-Car Corporation, Detroit, Michigan

TRI-LEVEL AUTO CARRIER

and total weight is reduced approximately 5,000 pounds or 10%. Production is more economical, too, because the ductility and formability of GLX-W permits four of the bends in the deck to be performed in one press operation. ◆ The GLX-W series of high-strength steels consists of fine-grained, semi-killed mild carbon steels, treated with varying amounts of columbium. The high strength of GLX-W permits designers to reduce the amount of steel and effect considerable cost savings when replacing mild carbon steel. GLX-W steels have a low carbon content and are readily weldable and formable. GLX-W steels are available at four minimum yield strength levels: 45,000, 50,000, 55,000 and 60,000 p.s.i. and in sheets, plates and bars. For complete technical information, write Great Lakes Steel Corporation, Product Development, Dept. MD-9, P. O. Box 7310, Detroit 2, Michigan.





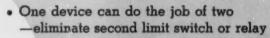
GREAT LAKES STEEL
Detroit 2, Michigan

DOUBLE the Poles in the Same Space

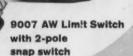
NEW O

Square D 2-pole Limit Switch

CUTS COSTS—
IS THE MOST COMPACT



- Control 4 circuits with 2-pole double-throw switch
- · Cuts installation time
- · Most compact of any 2-pole switch
- · Saves mounting space
- Mounts interchangeably with other 9007 AW limit switches
- Simplifies circuitry—and simplified circuitry means greater dependability

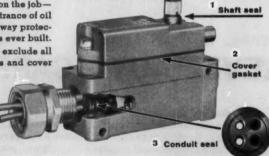


THE COMPLETE ANSWER TO LIMIT SWITCH OIL-TIGHTNESS!

The <u>real</u> test of a limit switch is how it performs on the job and the most common cause of trouble is the entrance of oil or coolant. Square D limit switches have three-way protection that makes them the most oil-tight switches ever built.

An effective shaft seal (1) and cover gasket (2) exclude all oils and coolants. However, even the best seals and cover

gaskets cannot prevent entrance of condensation and leakage into the switch through the conduit system. Square D has solved this problem with a new and inexpensive optional conduit seal (3) which fits the conduit entrance of AW and T limit switches, and completely excludes all liquids.



Get the Complete Story! Write Square D Company, Dept. SA, 4041 North Richards Street, Milwaukee 12, Wisconsin



SQUARE TI COMPANY

wherever electricity is distributed and controlled

TURBINES:

Shell reveals three ways that Turbo Oils help prevent oil breakdown, rust, sludge and foaming

Small quantities of air and water can work their way into any turbine lubrication system. These contaminants can accelerate oxidation of the oil.

Read how Shell scientists developed a specific formulation that counters this oxidation and brings you turbine lubricating oils with top performance records.

WHEN oxygen attacks turbine oil, it can form peroxides and organic acids. A chain of oxidation reactions begins. If the oil stability is inadequate, sludge can form.

Air entrained in the oil can aggravate oxidation. And it may cause foaming.

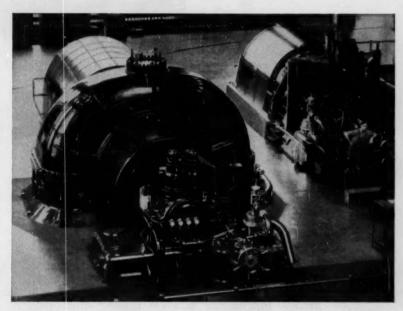
The oil may also be affected by water in the system. Laboratory tests have shown that water can greatly accelerate an oxidation process.

With Shell Turbo® Oil, Shell tackles these problems in three key ways:

- 1. Shell carefully selects base oils for use as turbine lubricants, then refines them to get the most effective response to Shell's special additives.
- 2. Shell adds a powerful oxidation inhibitor to its precisely refined base oils. This inhibitor helps prevent the chain of oxidation reactions caused by oxygen exposure at operating temperatures. It helps keep the oil in good condition, and lengthens its service life.

The result is that Shell Turbo Oils have proved themselves unusually stable over long service periods.

3. Shell uses an outstanding rust inhibitor. As a protective measure, Shell uses special additives that cover metal-



Shell Turbo Oils lubricate turbines with total rating of more than 17 million kw in the U. S. and Canada.

lic surfaces with strongly adherent polar-type films.

These films are designed to help keep water from the metal surface.

A message to manufacturers of turbine equipment

There are several grades of Shell Turbo Oil. One of them suits your equipment.

- 1. Your customers can get Shell Turbo Oils at Shell depots everywhere. Readily available throughout the world.
- 2. Quality is consistently high. Shell Turbo Oils always deliver top performance.

In drastically accelerated laboratory tests, metals immersed in Shell Turbo

Oils show outstanding anti-rust performance—even in the presence of sea water.

Ask your Shell Industrial Products Representative for facts on Shell Turbo Oils. Or write: Shell Oil Company, 50 West 50th Street, New York 20. New York.



A BULLETIN FROM SHELL

-where 1,997 scientists are working to provide better products for industry

Compact, low-cost SINCLAIR-COLLINS PILOT VALVE

PROCESS
INSTRUMENT
OR
CYCLE TIMER



for instrument or timer-actuated precision piloting

Looking for a means to amplify pneumatic signals originated by process instruments or cycle timers? Sinclair-Collins Model C-786 valves, diaphragm-operated by the source signal, assure near-instantaneous response for precise control of large pilot-operated valves and similar devices. They feature extremely short stem travel, from closed to fully open, and a flow area equal to ½ in. standard pipe.

Space a problem? The Model C-786 measures but 5% in. high ... is only 3% in. in diameter. Cost a problem? You'll find this valve, with all the built-in quality features found in every S-C valve, priced attractively.

Models for air, steam, hot or cold water, or inert gas service; bronze, ductile iron or stainless steel bodies; 2 or 3-way; 20 to 50 psi signal, 125 psi main valve; tapped ¼ in. NPT. Ask your nearby Sinclair-Collins Field Engineer to show you how the Model C-786 fits your instrumentation control system.

The SINCLAIR-COLLINS VALVE Co.

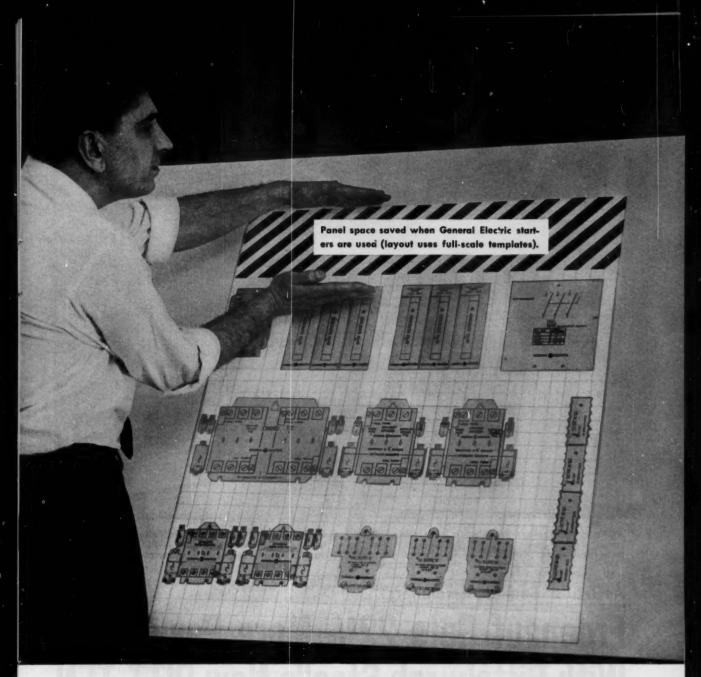
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (18EC)

AKRON 11, OHIO

For more information, write for Bulletin 59-SC. Address The Sinclair-Collins Valve Company, Akron 11, Ohio, Dept. MD-661.

MAIN

VALVE



The Size of This Panel Shrunk 12%, Construction Costs Dropped When General Electric Starters Were Used

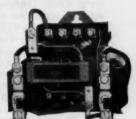
The panel above was first laid out with another make magnetic starter. Then, General Electric starters were substituted, and size was reduced 12 percent. Space savings like this mean important savings in steel and construction costs. You might even make the panel an integral part of your machine rather than mount it separately. Or perhaps you'll be able to use a *standard*

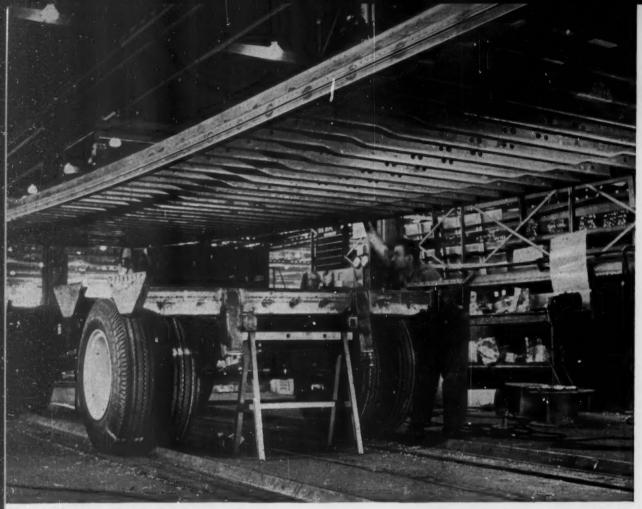
enclosure rather than a larger, more costly special. Since G-E starters are smaller and have full-front accessibility, you can locate wiring channels closer together, considerably reducing vertical panel space. Your G-E sales engineer can show you many more MEASURABLE ADVANTAGES. Call him today, or write for Publication GEA-7020. General Electric Co., Section 811-17, Schenectady 5, N.Y.

Progress Is Our Most Important Product

GENERAL & ELECTRIC

Circle 231 on Page 19





At Fruehauf Trailers' huge Avon Lake, Ohio, plant, crossmembers made from PITT-TEN high strength structural sheet provide 22 percent more payload.

Here, on the assembly line, a Fruehauf trailer bed made with Pittsburgh Steel Co. PITT-TEN is swung onto the underconstruction assembly.

As Trailer Bed Crossmembers

Fruehauf Gets 22% More Payload With Pittsburgh Steel's New PITT-TEN

Twenty-two percent more payload—that's what Fruehauf is building into the framework of giant trailers assembled with crossmembers made of PITT-TEN, Pittsburgh Steel Company's new high strength structural sheet.

Fruehauf uses PITT-TEN #1 at its Avon Lake, Ohio, plant—the largest trailer manufacturing facility in the world—because it offers a combination of benefits that . . .

- Cuts deadweight with no loss of strength
- Lengthens service life through superior corrosion resistance

• Light Yet Strong — Fruehauf tries to make its trailers as light as possible with no sacrifice in strength. Trailer bed crossmembers made of high strength PITT-TEN are lighter, for equal strength, than mild steel.

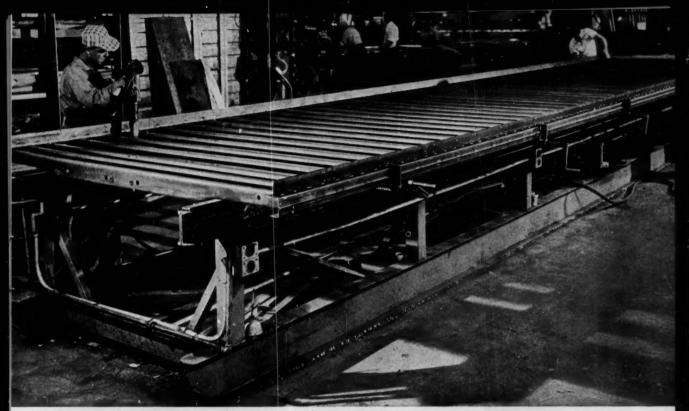
The weight saving amounts to more than eight pounds for each piece. That's because three pounds of PITT-TEN do the work of nearly four pounds of ordinary sheet steel. At the same time, it provides all the strength needed for years of hard use.

Corrosion resistance is another

problem in trailer operation. Fruehauf trailers are used under all types of conditions that could create maintenance headaches if the proper material were not used.

PITT-TEN \$1 has four to six times the resistance of carbon steel to atmospheric corrosion. So, Fruehauf specifies PITT-TEN to reduce maintenance costs.

The trailer part basically is a channel 93% inches long, 2 inches deep and 3 inches wide. Its width is expanded to 4½ inches on one side by an offset that extends most of its length. In addition, a ¾-inch



During assembly of Fruehauf trailer bed, crossmembers made from high strength structural PITT-TEN are riveted to the side rail. PITT-TEN #1 reduces maintenance requirements of Fruehauf

trailers through superior corrosion resistance. It has four to six times the corrosion resistance of carbon steel to atmospheric corrosion. PITT-TEN also cuts deadweight with no loss in strength.

return flange is applied full length to both edges.

Fruehauf engineers point out that forming this piece with offset and flange in high tensile steel would be a tricky business without consistent quality — and with PITT-TEN Fruehauf has a steel that does the job.

PITTSBURGH STEEL NEW SOURCE-This is one of several applications which mark the entry of Pittsburgh Steel in the high strength steel market, one of the fastest growing in metalworking.

That means this:

Fabricators of high strength steel structurals—or any product where the weight/strength ratio is a factor—now have a new source of supply.

In the eight years Pittsburgh Steel has been producing flat-rolled products, it has become recognized for the unexcelled quality of its steel sheet and strip. Now PITT-TEN is being produced by the same fine steelmaking and steel rolling facilities which have earned that reputation for quality.

PITT-TEN is produced in three grades, each with specific physical properties. Briefly, here they are:

PITT-TEN *1—An all-around high strength structural sheet that offers a combination of benefits. First is greater strength without increased weight; or equal strength with a lighter section. Second is longer product life, less maintenance through greater resistance to corrosion (four to six times that of mild carbon steel.)

PITT-TEN *2—high strength sheet with exceptional formability. This grade is produced to tensile and yield requirements to meet

forming problems of specific fabricated parts.

PITT-TEN "X"—produced to guaranteed minimum yield points of 45,000 and 50,000 psi. This grade is especially useful where the controlling factor is a reduction in weight without loss of strength.

If your product's success depends on weight/strength factors, then Pittsburgh Steel's new PITT-TEN can benefit you, too.

Let one of our service metallurgists show you how. They're as familiar with steel fabricating problems as they are with steelmaking problems. Just contact one of the sales offices listed here.

Pittsburgh Steel Company



Grant Building

Pittsburgh 30, Pa.

Warren, Ohio

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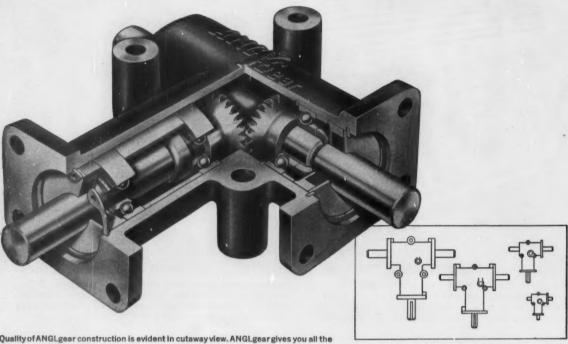
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Philadelphia



Circle 232 on Page 19

There is only <u>one</u> ANGLgear... and it is made <u>only</u> by Airborne



Quality of ANGL gear construction is evident in cutaway view. ANGL gear gives you all the features of other drives, plus greater hp range (1/3 to 5); permanent lubrication; and Conifiex* design gears for more even load distribution, reduced wear, quieter operation.

ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear-introduced in 1951—is the *original* standardized right-angle drive. It is also the No. 1 product in its field—in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date—for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it—for years.

*Trademark of the Gleason Works

And attention is seldom required.

Besides being maintenancefree, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, contact our local distributor, or write direct for new Catalog IA-58. ENGINEERS: Write for free ANGLgear design templates.

BASIC MODEL DATA

Medel	Тура	Gear Ratio	HP	RPM Dutput Shaft	Ultimate Static Torque ib. in. Dutput Shaft	Shaft Bia.	Wt., fb.
R-300	2-way	1:1	1/3	1800	250	3/8	.5
R-300-2	2-way	2:1	1/5	1800	250	3/8	.5
R-310	3-way	1:1	1/3	1800	250	3/8	.5
R-310-2	3-way	2:1	1/5	1800	250	3/8	.5
R-320	2-way	1:1	1	1800	1000	5/8	2.2
R-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
R-330	3-way	1:1	1	1800	1000	5/8	2.4
R-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
R-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
R-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
R-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
R-335-2	3-way	2:1	2-1/4	1200	1500	3/4	9.0
R-340	2-way	1:1	5	1200	2500	1	14.5
R-340-2	2-way	2:1	5	1200	2500	1	14.5
R-350	3-way	1:1	5	1200	2500	1	15
R-350-2	3-way	2:1	5	1200	2500	1	15



Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

Circle 233 on Page 19

Look to

FAFNIR

for leadership in ball bearings



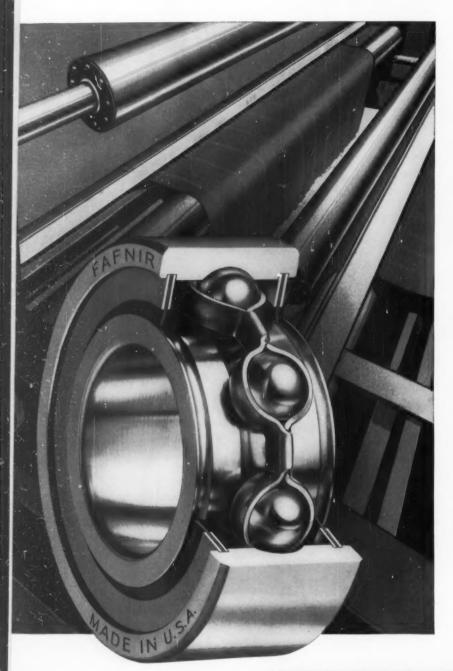


Rubber-cushioned ball bearings that run super-quiet

Modern air conditioning keeps a home comfortable... and does it *quietly*. One reason: Fafnir Super-Quiet Ball Bearings. Developed by Fafnir, these bearings are cushioned in current-conducting rubber to absorb noise. The bearings themselves are specially honed for silent service. Look to *Fafnir* for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

50 YEARS OF EXPERIENCE IN THE MANUFACTURE OF BALL BEARINGS FAFRINGS BALL BEARINGS

Look to FAFNIR



for stainless steel ball bearings that resist corrosion

Textile finishing can "finish off" bearings . . . fast! To control the corrosive effects of moisture, fumes, dyes, and acids, Fafnir developed stainless steel ball bearings with seals designed for extremely severe service. These bearings are used today in a wide variety of textile wet processing equipment. Look to Fafnir for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

FAIL BEARINGS

Look to FAFNIR

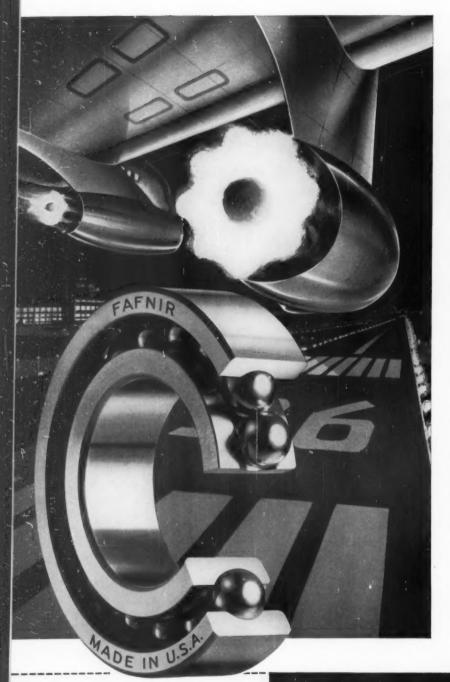


for miniature ball bearings of extra-clean vacuum-melt steel

Seconds after countdown, a microscopic pit in a miniature bearing could ground the most carefully planned space shot. To eliminate pits and other imperfections, Fafnir helped pioneer miniature ball bearings of vacuum-melt stainless steel. This "extra-clean" steel is completely free of impurities, and makes for flawless bearing performance. Look to Fafnir for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

FAFRINGS BALL BEARINGS

Look to FAFNIR



for cobalt-base alloy ball bearings that withstand high temperatures

Air bled from jet engines comes through hot. And the pressure is tremendous. For ball bearings that can stand these jet-hot heats and jet-high pressures, Fafnir turned to cobalt-base alloys. These "exotic" Fafnir bearings are ideally suited for turbodrive butterfly valves and similar high temperature, high load applications. Look to Fafnir for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.



MADE IN U.S.A.

This stamp on a Fafnir Ball Bearing means finest quality and workmanship . . . dependable supply . . . competent engineering help . . . and responsibility in meeting your bearing needs. It's worth bearing in mind.

THE	FAFNIR	B	EARIN	G	COMPANY
NEW	BRITAI	V.	CONN	EC	TICUT

Our ball bearing problem is Noise Corrosion

Miniaturization Heat. Other:

We'd like to talk it over with you and get Fafnir's ideas.

Name.

Position

Compan

City

Zone

FAIL BEARINGS

"The Roustabout", rugged, three-wheel truckworkhorse, powered by a K662 Kohler engine.

A model K91 Kohler engine powers the G. H. Tennant Co. Model 40 heavy duty sweeper for foundries, taconite plants-places with extreme dust conditions.



KOHLER ENGINES

Stamina that stands up ... and stands out

More and more Kohler engines are winning their place on new equipment by superior test performance . . . Long-term applications demonstrate their lasting reliability

... Built-in stamina pays off in extra staying power and cost-saving efficiency.

Quality engineering proves its value in action . . . Hot spark insures fast, all-weather starting . . . Large bore and short stroke design cuts engine friction, increases power and prolongs life . . . Balanced crankshaft reduces vibration.

Kohler Co. has manufactured internal combustion engines since 1920 . . . Sales and service nation-wide.

See us in Sweet's Product Design Catalog

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KOHLER Co. Established 1873 KOHLER, WIS.

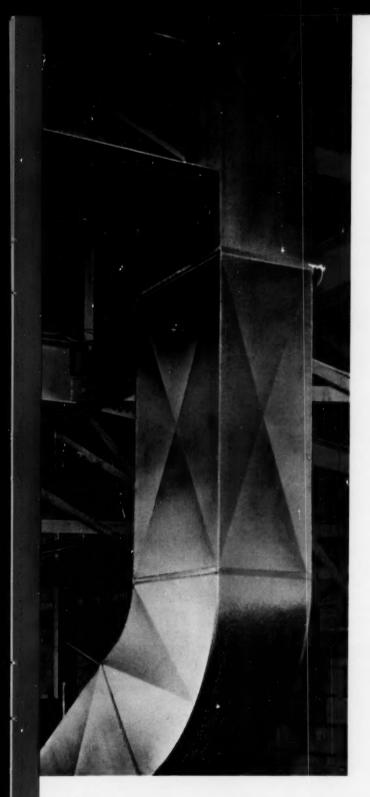
KOHLER OF KOHLER

ENAMELED IRON AND VITREOUS CHINA PLUMBING FIXTURES . ALL-BRASS FITTINGS . ELECTRIC PLANTS . AIR-COOLED ENGINES . PRECISION CONTROLS

4-cycle · Short stroke · Air-cooled

K331





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brand-new brand in hot dipped quality galvanized steel sheet

You can tell Youngstown tufkote by the bright new sparkle of its fine zinc coat. And durable tufkote performs as well as it looks. You can test it any way you want to prove its workability. Bend it to see how easily it forms. Draw it to watch its ductility.

tufkote comes from the newest, finest galvanizing line in the industry. The new 848-foot line at our Indiana Harbor plant incorporates every modern facility insuring zinc coated sheets in both cut lengths and coils, unequaled in superior quality.

tufkote offers the best combination of strength and bendability. You'll never see formation of oxide or dross. No "spikes" or "icicles". Nor will it flake or peel when you use it. tufkote will pass your stiffest inspection because it is carefully watched from ore to open hearth and rolling and through the precision Sendzimir zinc coating process itself.

Specify new Youngstown tufkote. Get the exact coating, finish and adherence your specs call for. And you get fast, dependable service that makes Youngstown higher quality an even greater value.



Youngstown - growing force in steel

For full details on new tufkete galvanized sheet, write, Dept. 10-B The Youngstown Sheet and Tube Company, Youngstown, Ohio

total retaining ring ideas

to help you cut costs - improve product design and performance

the unique 360° full-circle ring offers design variations that open unlimited opportunities for new and improved designs. Available in a variety of materials and finishes from .375" to 48" diameter.

SINGLE TURN RINGS

-for economy-light weight Internal or external rings provide positive positioning or retaining for light thrust applications.



RESILIENT RINGS-allow

large tolerances -end play take-up Eliminate need for separate springs and washers—available in waved or dished designs.



DOUBLE TURN RINGS

-medium-heavy-extra heavy duty standard series to choose from including the NAS 669/670 "deep groove" series.



BALANCED RINGS

-for critical balance operations Minimize dynamic balancing prob-lems on shafts with statically balanced rings - make ideal oil



MULTI-TURN RINGS

extra heavy duty-spacers Can be coiled to any diameter, any number of turns for heavy loading



GROOVE GUARD RINGS

-reinforce ring groove Single turn, high tensile strength rings greatly strengthen groove.



SELF-LOCKING RINGS

one piece-positive locking Locking action keeps ring in groove under high rotational speed, vibration, impact loading.



REMOVAL NOTCHES

-variety of end conditions available Rings can be supplied with removal notches, slots, tabs, or hooks -round, square, bevelled or tapered



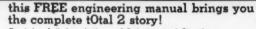
Spirolox Rings have no lugs or projections — uniform wall allows installation with minimum clearance - no special tools are needed for installation or removal. Prototypes require no special tooling or set-up charges. Spirolox lends itself to deep groove design to withstand greatly increased thrust load. Covered by Government Specifications MIL-R-27426 for usage under Government contracts. Ramco engineers will be glad to work with you on the solution of difficult problems.

or - you may find the answer in the improved die-formed retaining ring.

Circolox as well as Spirolox provides the answer to easy, lightweight, low cost assemblies and reduced manufacturing costs. Made in a variety of types and sizes for the smaller shaft and housing diameters. Check these Circolox features

- · "Deep groove" design permits maximum thrust with minimum weight
- · Easily installed or removed.
- · Available in a variety of materials
- · Wide choice of finishes available.
- · Always uniform in quality
- Meet Government and Industry Standards.

Convright 1961 Ramsey Corporation 990



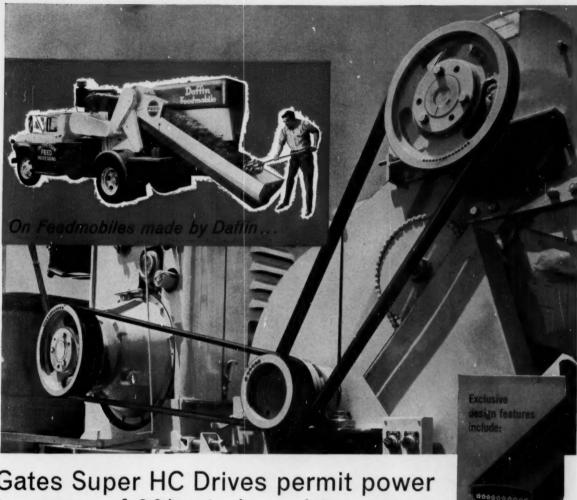
Contains full descriptions of Spirolox and Circolox Rings with complete design information and specifications. Write TODAY!

manufactured by

RAMSEY CORPORATION

a subsidiary of Thompson Ramo Wooldridge Inc.

Box 513, Dept. B, St. Louis 66, Mo.



Gates Super HC Drives permit power increase of 20hp in less drive space

The Daffin Feedmobile is a well-designed. efficient feed mill on wheels made by Daffin Manufacturing Co. of Lancaster, Pennsylvania. Originally, all the power for grinding, mixing and blending was transmitted by conventional V-belt drives.

Early in 1960, the machine was redesigned to obtain the competitive advantages that result through use of Gates Super HC High Capacity V-Belt Drives.

An official of the company, John Skinner, Jr., says: "The Gates Super HC Drives let us increase the output of the diesel power plant from about 100 HP to 120 HP without reducing the original safety factor. Sheaves are narrower and are about 80 pounds lighter, reducing the overhang load on bearings, increasing bearing life. Guards are 4 inches narrower, require less metal and are nearly 33% lighter weight. Drive cost for each machine has been cut 7 or 8%.

He says further: "The Gates High Capacity Drives have greatly strengthened one of our most important selling points-the fact that 'there is far less down-time with a Daffin.'"

Manufacturers everywhere have standardized upon the Gates Super HC V-Belt Drive -the first and most advanced high capacity drive. It is your best assurance that your power transmission unit will not soon become obsolete.

The Gates Fieldman located near you is a drive design expert. Contact him for technical information and assistance in designing Gates High Capacity V-Belt Drives.

The Gates Rubber Company, Denver, Colorado

Gates Super HC V-Belt Drives



precisely engineered

ave sidewalls. Flex

Weave cover, super

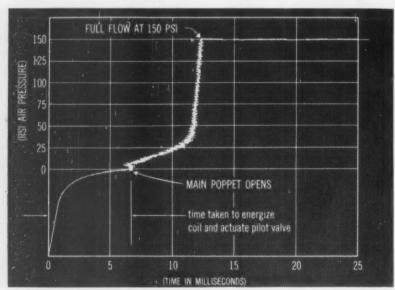
Gates Super HC

Drive saves space

'Mach 2' Air Valve Gives 12 Millisecond Response

Oscilloscope tracks valve action from 0 to full flow at 150 psi

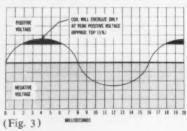
Twelve milliseconds is the time required to energize the solenoid coil, actuate the pilot valve, and bring the main poppet of a "Mach 2" air valve into fully open position at 150 psi. To record the instant response that eliminates lag in air-automated operations, a Crescent "Mach 2" 4-way air valve was tested by the American Laboratory, Los Angeles, California. A camera located over the oscilloscope screen (Fig. 1) photographed the response action. Tests were made with a 12 volt DC coil in the de-energized position, poppet No. 1 in the closed position, and a system pressure of 150 psi. The graph (Fig. 2) was drawn from a photograph of the oscilloscope screen. The curved line in the lower section of the graph indicates the time required to energize the coil and actuate the pilot valve. The heavier line, above, is the oscilloscope's registration of the increase in pressure as poppet No. 1 moved from closed position to full open position where 150 psi line pressure was reached. Total elapsed time is 12 milliseconds.



(Fig. 2

Corresponding results on AC current

Tests were run, also, on AC voltages and identical fast response was registered when coil actuation began at the positive peak of the AC sine wave. As indicated in Fig. 3, a wave length of AC current is approximately 16 milliseconds in duration. A coil will not energize until voltage has reached approximately 85% of capacity. The energized period represents 15% of the sine wave or 4 milliseconds. Therefore, additional milliseconds will be added to response time up to 12 milliseconds.



seconds if the peak of the sine wave is not caught. Thus, the response time of a "Mach 2" air valve on AC voltage is from 12 to 24 milliseconds. This fast action is positive assurance against lag in operations where instant response is imperative – sorting, counting, discarding sub-weight containers, spot welding, etc.

High speed PLUS dependability

The fast response of "Mach 2" air valves is attributable to original design advances that also dramatically improve endurance. These new air valves are rated at 1000 cpm continuous duty, and cycling speeds to 2100 cpm have been maintained for intermittent periods of 20 minutes. Control of coil heating and drastic reduction of friction in the solenoid and pilot valve sections are essential for this kind of performance. The extremely short stroke of the "Mach 2" solenoid plunger (3/32" – approximately the



(Fig. 1

thickness of a nickel) fractions the time the coil is energized; heat generation drops and response is stepped up. Coil life is guaranteed for a minimum of 100 million cycles.

Friction drastically reduced

In the pilot valve, a tiny ball seats on "O" rings at both ends of a pilot cartridge. The ball moves freely, independent of the seals. There is no "O" ring drag on the pilot plunger because it requires no seals; where there is no friction there can be no wear. The main valve seats seal on "O" rings, and metal shoul-

ders take the shock in such a way that the "O" ring seal is merely kissed by the seat in the sealed position. As the rings are only minutely flexed, they do not fatigue or lose their resilience.



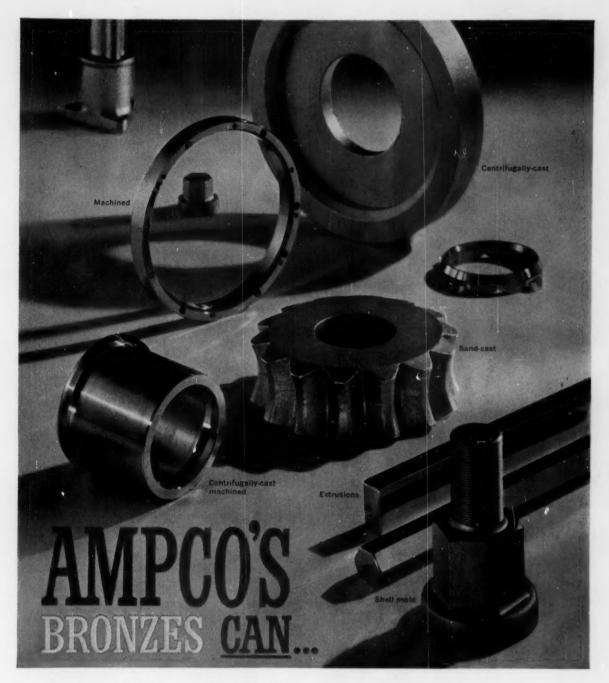
PILOT CARTRIDGE

Write for your "Mach 2" catalog

The 12 millisecond response and long service life of "Mach 2" pilot operated air valves are sound recommendations for the installation of these field proven units. They are available in \(\frac{4}{a}\) to \(\frac{3}{a}\) pipe sizes. For your "Mach 2" catalog write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California.



"Mach 2" 4-Way Valve



when other metals can't!

If your operation is so punishing on metal parts that you're plagued with constant, expensive replacement — better look into Ampco's bronzes!

Ampco alloys work where other metals wilt. The peculiar—but desirable—characteristics of these copperbase alloys make them ideal for applications that destroy most metals. Corrosion. Erosion. Physical attack, like abrasion . . . or metal-to-metal wear. All of these abusive forces are countered by Ampco!

Ampco's two basic products are AMPCO® metal, a

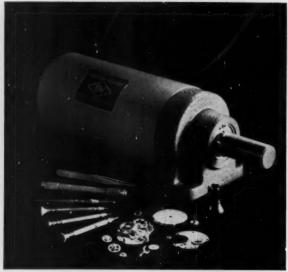
premium quality bronze that costs a little more, but delivers a lot more . . . and AMPCOLOY*, a series of better-than-usual commercial grade bronzes. All are available in sand-cast, centrifugal-cast, shell-molded, extruded, rolled, wrought, forged, fabricated, and finished-machined forms from Ampco's unmatched metal-producing facilities.

Get the whole story on these miracle-metals. Write for "AMPCO"— a full color, illustrated booklet — yours for the asking.

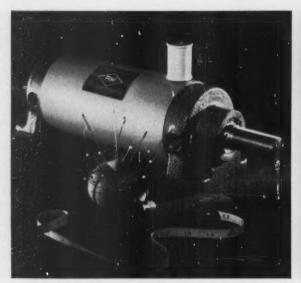
AMPCO METAL, INC., MILWAUKEE 1, WISCONSIN / HUNTINGTON PARK, CALIFORNIA / GARLAND, TEXAS



DEPENDABLE NAME, DEPENDABLE PRODUCT



QUALITY MATERIALS AND CRAFTSMANSHIP



TAILORED TO FIT YOUR NEEDS



FAST, DEPENDABLE DELIVERIES

All yours with Bendix-Westinghouse Power Cylinders

Dependability . . . quality . . . specialized engineering . . . quick delivery. If you're seeking these features in power cylinders, your best source is Bendix-Westinghouse. Our experience has been earned in nearly every imaginable application—light, medium and heavy-duty—standard and special—involving pressures up to 200 psi air and 1800 psi oil on standard models, higher on specials. We maintain a large inventory of machined parts for standard units, and offer the flexibility to

"tailor" power cylinder sizes and mounting arrangements to your needs quickly and accurately. Write or call for complete information on industrial product applications involving power cylinders from Bendix-Westinghouse.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 paid air pressure.



ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

Bendin-Westinghouse (BW)

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

EXOTIC

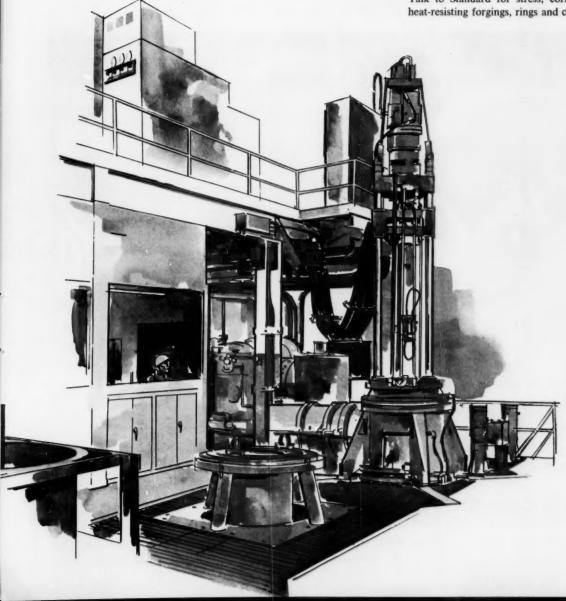
STEELS

FROM STANDARD

The vacuum arc remelt furnace pictured below is producing some of the largest ingots of the most advanced alloys in commercial production today—superstrength alloys for missiles, such as D-6, AMS-6428, 300M, and special high-temperature alloys for gas turbine, jet engine applications, A286, Waspalloy—to name a few.

This facility rounds out the most modern integrated steelmaking plant for special alloy forgings and rolled rings in the country—electric furnace steels, vacuum degassed, and vacuum remelted.

Talk to Standard for stress, corrosion and heat-resisting forgings, rings and castings.







QUALITY CONTROL IS SECOND TO NONE AT STANDARD. Quality control at Standard is maintained by the most accurate, up-to-date testing equipment available. Laboratory facilities operate day and night to support our metallurgists, shop foremen, mill and machine operators—as well as plant management and, of course, our customers.

STANDARD'S OPEN-DIE FORGINGS SUPPLY NATION'S LEAD-ING INDUSTRIES. Steel and nonferrous alloys can be worked in Standard's forge shop, including some hard-to-work metals such as titanium and super alloys. It can turn out forgings from 15 to 52,000 lb.; up to 45 inches in diameter; and up to 60 ft. in length. Major products include rotors and wheels for turbines, propeller shafts for ships, rolls for sugar, printing and rubber industries.

Standard's hundreds of customers represent every major industry in the world. Metal components of carbon and alloy steels, super alloys, and nonferrous alloys such as aluminum and titanium are supplied by Standard for an endless line of products. What particularly impresses our customers however, is the unique, personalized service we provide. See for yourself—bring your next problem to Standard.





STEEL CASTINGS TO VIRTUALLY ANY SPECIFICATIONS. The Standard foundry, one of the larger ones in the country, has turned out castings as light as 1 lb., and ranging up to 85,000 lb. They include some of the largest heads ever cast for dredge cutters and also vital components in huge hydroelectric projects throughout the world. Standard yields to none in the skill of its foundry engineers, metallurgists, molders, coremakers and core setters.

PIONEERS IN ROLL-FORGED RINGS . . . STANDARD. Standard's craftsmanship in forming metal rings for heavy industry dates back to 1856. The first all-forged weldless rings were produced in volume for the first time in 1870—at Standard. And much of the development work in forging weldless rings of high-alloy steels, aluminum and titanium has been done in Standard's Ring Department.

Standard Steel Works Division BALDWIN LIMA HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes



Solve Multi-Point Temperature Control Problems...

at ¾ cost of competitive systems

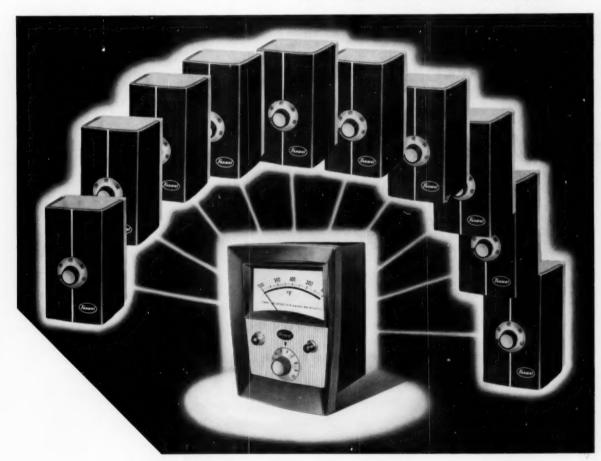
You get them all — wide ranging versatility . . . maximum sensitivity . . . easy installation and servicing! These features combine in a Fenwal 536-580 multi-point monitoring system to give you precise, transistorized temperature control and indication. And you choose the features you need to suit your own requirements!

Examine these cost saving advantages: Indication and control circuits are separate . . . the 536-580 system eliminates the need for separate indication and control at each point. You can build a control system concurrent with your needs — start with 2 points and build up to 10 points without paying a premium at the outset. The complete control system is built from standard catalog parts, thereby eliminating the need to buy costly "specials" for servicing at a later date.

Individual points can have either proportioning or ON/OFF control modes. The system permits "flick of switch" indication of from 2 to 10 temperatures. Individual set points can be adjusted from a central control panel or through a separate potentiometer remotely located. You select your own number of points and you pay only for the options you use.

Choose from five standard temperature ranges — from -50 to 600°F... expanded scales permit fine temperature adjustments and improved readability, and the entire system gives you sensitivity to within 0.1°F.

Both instruments are smartly styled to perfectly complement modern industrial machines and interiors. A Fenwal engineer will be glad to supply information on this system, or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 196 Pleasant Street, Ashland, Mass.



Another example of how



CONTROLS TEMPERATURE . . . PRECISELY

What's News in Rubber...



ENJAY BUTYL HT 10-66 gives this playground mat the ability to withstand years of scuffing and abrasion, repeated impacts and flexing, as well as outdoor weathering.

A NEW RUBBER TO DO THE HARD JOBS! ENJAY BUTYL HT 10-66

Halogenated for...high heat resistance...covulcanization with other elastomers...low compression set...and faster cures

Plus these well-known Butyl advantages:

- High flex, tear and abrasion resistance
- Excellent chemical resistance
- Low gas and moisture permeability
- High weather and ozone resistance

NOW AVAILABLE IN A VARIETY OF MOLECULAR WEIGHTS



AIR-HOLDING INNERLINERS of Enjay Butyl HT 10-66 help assure correct inflation pressure for tubeless tires and can give greater blowout protection as well as improved tire-tread wear. Other tire uses include white sidewalls, black sidewall veneers and chafer strips.

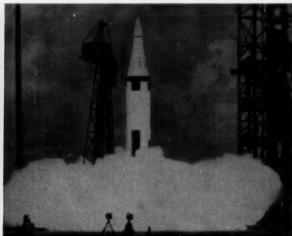


APPLIANCE PARTS of Enjay Butyl HT 10-66 withstand the deteriorating effects of detergents and dishwashing compounds. Absorption of hot water by the rubber is reduced to a minimum.

HOT MATERIAL BELTS like this perform well at continuous temperatures of 350°F, thanks to the exceptional heat aging properties of Enjay Butyl HT 10-66.

SHOCK-RESISTANT LAUNCHING PADS of metal-covered Enjay Butyl HT 10-66 withstand launching shock and exposure to intense heat encountered in missile firings.





WRITE TODAY FOR NEW TECHNICAL MANUAL HT 10-66...

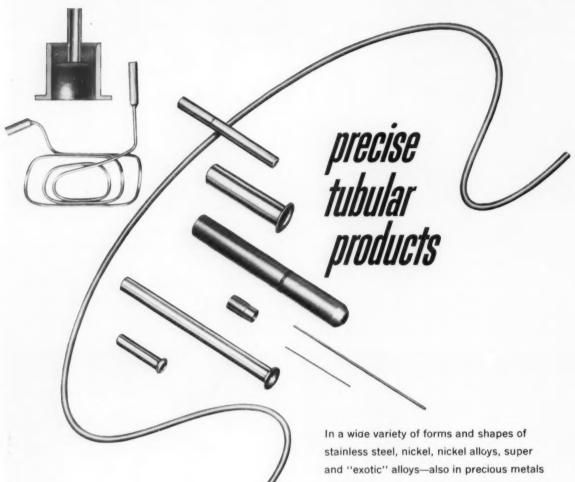
Contains processing information, performance data and recommended cure systems. For your free copy or for technical assistance in applying this important new polymer, write to Enjay, 15 West 51st St., New York 19, N. Y.

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ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY





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And a complete line of seamless, welded, and drawn tubing up to 1" O.D.

Write for Bulletin No. 12

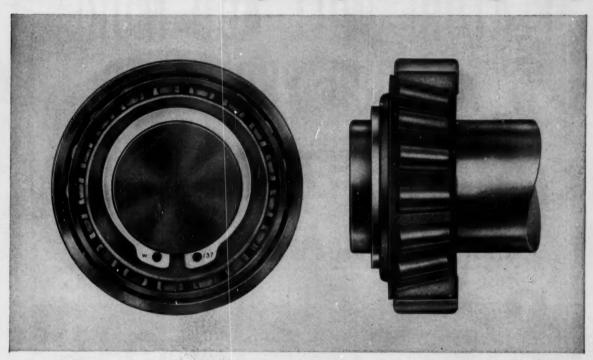




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NEW! Waldes TRUARC Series 5160 Heavy-Duty Retaining Ring



for thrust and impact...for retaining bearings ...for a new approach to heavy-duty fastening

Now you can enjoy the benefits of a truly heavy-duty fastener — with all of the advantages and production economies retaining rings provide. The new Truarc Series 5160 is a unique external ring designed to secure components on shafts, axles and similar structural members. It has high thrust load and impact resistance and forms a shoulder sufficiently high to retain parts having large corner radii or chamfers. The Series 5160 is ideal for retaining bearings. You can use it without spacer washers to secure ball bearings, tapered roller bearings (shown above) and cylindrical roller bearings—all having large corner breakouts. The ring eliminates the need for machined shoulders, costly heavy-duty nuts

and other bulkier and more expensive fastening devices normally required for extreme loading conditions. The Truarc Series 5160 is available in 11 popular sizes for shafts ranging from .473" to 2.0" dia. — and other sizes are on the way. You can order the Series 5160 in carbon spring steel or — for corrosion resistance and high temperature limits — in Armco PH 15-7 Mo stainless steel. Sizes up to 1.378" also are available in beryllium copper. For complete specifications, write for Truarc Data Bulletin No. 459-11. Better yet, contact your local Truarc Representative or Distributor. They're listed in the Classified Telephone Directory under "Retaining Rings" or "Rings, Retaining."

SEE FOR YOURSELF — Send for a free sample of the Truarc Series 5160 Heavy-Duty ring. We'll include a standard external ring of the same size for comparison. You'll see the difference as soon as you open the envelope!

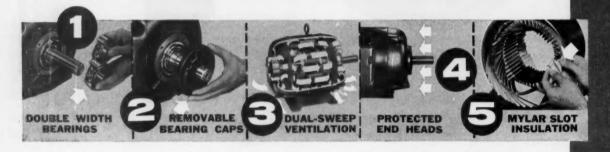
WALDES KOHINOOR, INC.

47-16 Austel Place, Long Island City 1, New York

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WHICH R&M MOTOR FEATURE WILL ADD MORE TO YOUR PRODUCT'S COMPETITIVE ADVANTAGE?



All these outstanding features—yours at no extra cost—contribute to R&M's dependable performance, easy maintenance and long life. Fully sealed double-width bearings have extra-large reservoirs containing grease selected to resist dust, temperature, humidity and high speeds. Bearing inspection and relubrication are easy. Bearing cap on each end head comes off quickly when four bolts are removed. Bearing seal, held by removable snap rings, is also easily removed. "Dual-Sweep" ventilation greatly prolongs motor life with high-velocity cooling and cleaning. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas. Venturi baffles direct air over and around end coils. One-piece shrouded end heads give full-height protection against moisture and falling objects. Mylar* laminated to rag paper insures positive slot cell insulation because of its excellent dielectric qualities (8 times that of conventional insulation). Rag paper backing provides cushion against abrasion and puncture. Get complete information . . . write today for Bulletin 520-MD

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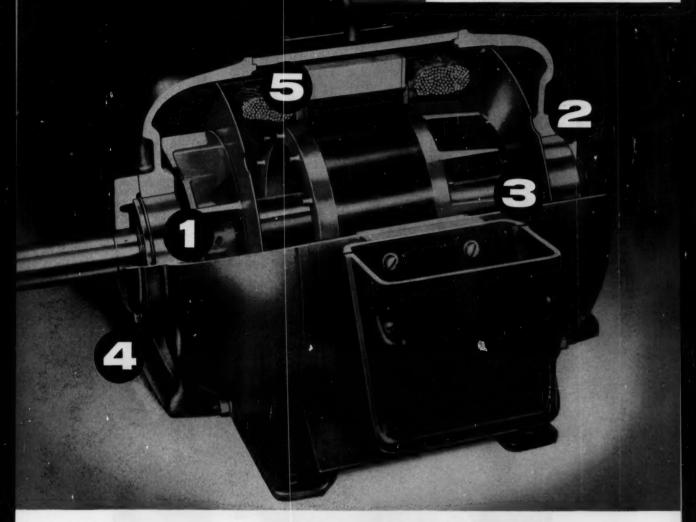
ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors * Electric Hoists and Overhead Traveling Cranes * Moyno Industrial Pumps
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Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.



MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)

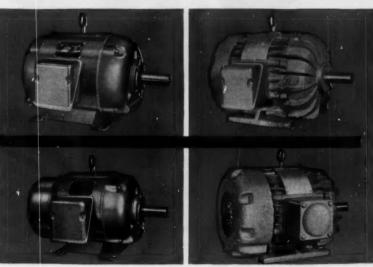


Open Protected Polyphase Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.

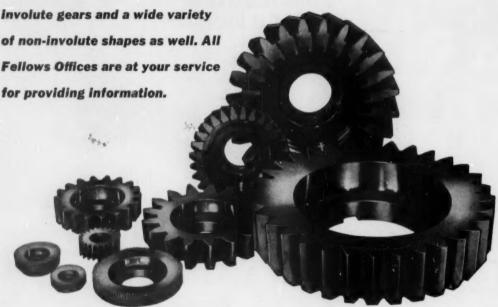


WHY RISK LOSS OF GEAR SHAPER PERFORMANCE?

Give your products <u>all</u> the high-production, high precision advantages of Fellows Gear Shaper performance by tooling up with Fellows cutters.

The <u>better</u> design of Fellows cutters is the result of advanced engineering techniques, including the use of a high-speed computer for solving design and application problems. Their <u>better</u> quality is the result of constant advances in metallurgy and manufacturing methods. And, proof of their <u>better</u> performance are the thousands of Fellows cutters in use on modern gear production lines.

Fellows cutters on Fellows machines lower costs and speed production on external and internal, spur and helical



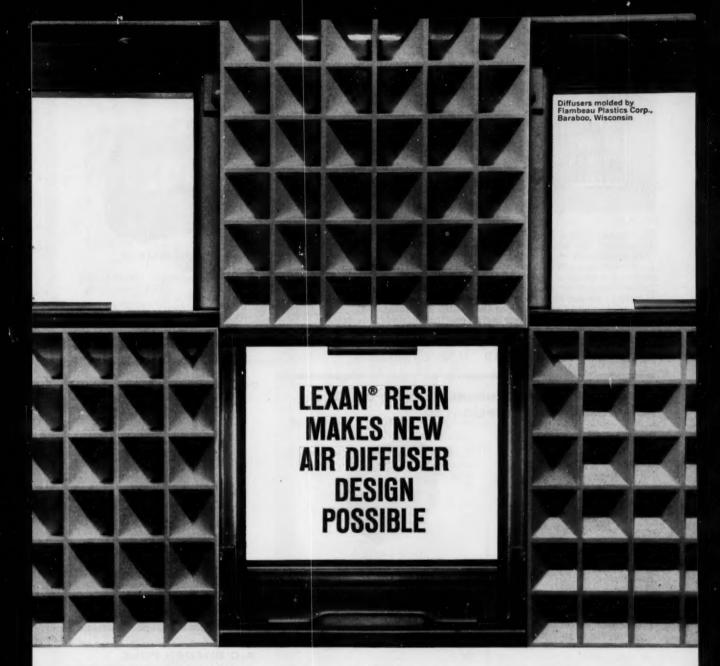
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Fellows

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Gear Production Equipment



A new concept in air distribution pioneered by Carnes Corporation of Verona, Wisc.— made a reality by LEXAN polycarbonate resin!

In Carnes' design, 6-by-6-inch air diffusers, like those above, form modular units which can be arranged in any desired ceiling pattern. Three different module designs provide complete flexibility in directing air.

"LEXAN resin is the only material we have approved for our diffusers," says Gordon Sylvester, Chief Product Engineer of Carnes. "We tried polystyrenes, polyethylene, nylon and others, but they all fell short in one way or another."

The material for Carnes' diffusers

had to meet this combination of requirements: • INJECTION MOLDING for low production cost. LEXAN resin, as a thermoplastic, gave this advantage. • NO HEAT DISTORTION in 225°F. test for handling warm air. In month-long tests of parts, LEXAN resin met this spec. Actually, the resin's rated distortion point is 270-280°F. under load. · DIMENSIONAL STABILITY in use. LEXAN resin was stable. . FLAME RETARDANCE to pass ASTM test. LEXAN resin passed. . COLOR STABILITY and versatility. Although the modules are now a stable white, LEXAN resin offers the possibility of a wide range of colors. . HIGH IMPACT RESISTANCE. Frank Freese, Product and Merchandising Manager for Carnes, really sells LEXAN resin's enormous impact strength. He says "In demonstrating the strength of the modules, we slam them against the wall. It doesn't damage them at all. Metal diffusers would be bent by this treatment."

LEXAN resin has raised the quality of many designs to new levels. It's been substantially reduced in price as new G-E plant facilities have come onstream. Can this tough new thermoplastic help you? Send for design literature. Address General Electric Company, Chemical Materials Dept., Section MD-61, Pittsfield, Mass.

LEXAN'

Polycarbonate Resin

GENERAL 3 ELECTRIC

Circle 248 on Page 19



select the motor needed for your application

Did you know that Barber-Colman Company makes both a-c and d-c motors? On these pages we have tried to tell very briefly a little about each of our motors. Featuring high quality at low cost, Barber-Colman 115 volt a-c (6-220 volt optional) shaded pole motors are excellent for commercial and industrial applications. Barber-Colman d-c precision motors are available in a variety of voltage ranges, styles and specifications to meet airborne and industrial applications. Look at the motors illustrated and then ask us for more literature on the one that interests you most.

BARBER-COLMAN COMPANY ROCKFORD, ILLINOIS

A-C SHADED POLE UNIDIRECTIONAL MOTORS FOR COMMERCIAL APPLICATIONS



AYAA - DYAA - KYAA

Specifications:
Rated horsepower .0007 to .0010
Length 1-1/8" plus shaft
Dimensions ... 2-7/32" x 2-1/4"
Remarks ... Exceptionally small
and compact

and compact
Typical applications — fan blades,
blowers, reroll chart drives, phonographs, and gear trains.



DYAB - KYAB



DYAF-KYAF-OYAF-CYAF

Specifications:
Rated horsepower .0045 to .032
Length 1-5/8" to 2-9/16"
plus shaft
Dimensions ... 2-21/32" x 2-3/4"

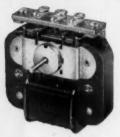
pius snatt
Dimensions... 2-21/32" x 2-3/4"
Remarks....High running torque
Typical applications — fans for
heaters, deodorizers and electronic equipment; blowers and
gear trains.



AYAR - BYAR - CYAR - DYAR

Specifications:
Rated horsepower .005 to .050
Length 1-29/32" to 3-11/32"
plus shaft
Dimensions 3-1/8" x 3-1/4"
Remarks High start or high
power rotors available
Typical applications — pumps,
humidifiers, vaporizers, combustion and industrial controls.

A-C SHADED POLE REVERSIBLE MOTORS



AYAE-DYAE-KYAE

sitioning devices, and pen drives.



OYAE

A-C SHADED POLE SYNCHRONOUS MOTORS

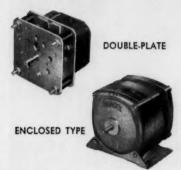


DYAJ — KYAJ

Specifications:
Rated horsepower .0043 to .0086
Length 1-3/4" to 2-1/8" plus shaft
Dimensions . 2-11/32" x 2-19/32"
or 2-23/64" x 2-19/32"
Remarks . . Develop 30 times power
of ordinary clock motors
Typical applications—oscillographs,
scoreboard timers, viscometers,
facsimile recorders, x ray timers,
and microfilm cameras.

A-C GEARED MOTORS

SYNCHRONOUS UNIDIRECTIONAL REVERSIBLE



Barber-Colman a-c geared motors provide ratios from 4:1 to 1,333,800:1. Heavy duty gears and output shaft plus long life lubrication add to the reliability of these geared motors.

A-C 400-CYCLE MOTORS



AYLO

A-C & D-C TACHOMETER GENERATORS

For Commercial Installations



Type DYAE a-c reversible shaded pole motor acts as a low-cost, rugged, accurate, and dependable a-c tachometer or rate generator.

DYAE

Precision For Military Usage



BYLM and FYLM generators are capable of output voltages up to 40 volts per 1000 rpm, with high linearity and low ripple content. Excellent for servo rate feed back.

6-115V D-C PRECISION PERMANENT MAGNET, REVERSIBLE MOTORS FOR AIRBORNE AND INDUSTRIAL APPLICATIONS



BYLM

Specifications: Rated horsepowerup t	to 0.1
intermittent duty	
Rated speed . 5,000 to 20,000	rpm
Power input 7 to 155	
Length 2.19" to	3.19"
excluding shaft	
Diameter	1.50"



Specifications:
Rated horsepower up to .055
intermittent duty
Rated speed . 5,000 to 20,000 rpm
Power input 2 to 70 watts
Length 1.77" to 2.40"
excluding shaft
Diameter 1.25"
Features .constant brush pressure;
R3 bearings; 3/16" dia. shaft



DYLM — EYLM

Specifications (E I LM only):
Rated horsepower up to .055
intermittent duty
Rated speed . 5,000 to 20,000 rpm
Power input 7 to 155 watts
Length 1.83" to 2.45"
excluding shaft
Diameter 1.38"
DYLM is a split series motor in
the same envelope





HYLM

Typical Specifications (27 volts):
Horsepower
intermittent duty
Torque 1.0 oz-in.
Speed 17,000 rpm
Power input 23 watts
Length 1.59"
Diameter 1 00"

GEARHEADS, BLOWERS, RIGHT-ANGLE DRIVES, FILTERS, GOVERNORS, MAGNETIC BRAKES

Barber-Colman d-c motors can be adapted to a variety of uses. Several sizes and styles of blowers and gearheads are available. Rightangle drives and multiple-shaft outputs can also be had for special applications. Radio noise filters, governors, or magnetic brakes furnished if required.

D-C BATTERY-OPERATED MOTORS



вуом

Voltage rangeapprox. 3 to 30
Governed speed
approx. 1200 to 6000 rpm
Torque 0 to .20 oz-in.
Maximum dia 1.29"

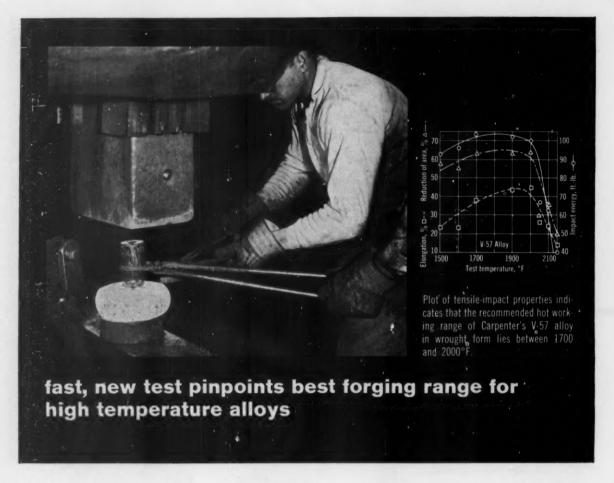


HYOM

піфіп
Voltage range 4.5 to 30 volts
Governed speed 1500 to 5000 rpm
Torque 0 to .20 oz-in.
Maximum dia

BARBER-COLMAN COMPANY

Dept. R, 1973 Rock Street, Rockford, Illinois



A fast, easy and economical, new Carpenter test takes much of the guesswork out of hot working high temperature alloys. The results, when correlated with other Carpenter test data and mill experience, reveal the best working temperatures—help forge shops get better finishes with less machine clean-up . . . less wasted steel . . . fewer rejects . . . faster fabricating.

Based on tensile-impact . . . Using a modified tensile-impact test method, impact strength, elongation and reduction of area in an alloy are determined over a range of temperatures. By plotting tensile-impact properties as a function of temperature, the hot working range of the alloy can quickly be established. (see chart)

New, improved Carpenter techniques and quality controls like this, are your best assurance of easy forgeability and consistent uniformity in high temperature alloys. For details, or data on Carpenter's VACUMELTROL® and CONSUMET® vacuum melted products, call your Carpenter representative today.

Carpenter steel

you can do it consistently better with Carpenter Specialty Steels for specialists



The Carpenter Steel Company, Main Office and Mills, Reading, Pa. Export Dept., Port Washington, N.Y.—"CARSTEELCO"

Alloy Tube Division, Union, N.J. Webb Wire Division, New Brunswick, N.J.

Webb Wire Division, New Brunswick, N.J. Carpenter Steel of New England, Inc., Bridgeport, Conn.







Gears for Every Purpose ... one gear or 10,000 or more

2108 NORTH NATCHEZ AVENUE .

CHICAGO 35, ILLINOIS

Send ESNA YOUR ROLLPIN® NEW-

WHERE CAN YOU USE THIS SIMPLE FASTENER?



ROLLPIN is the slotted tubular spring pin with chamfered ends that is cutting production and maintenance costs in every class of industry. Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. ROLLPIN is readily removable and can be re-used in the same hole. Made in carbon steel, corrosion resistant steel and beryllium copper.

Valuable prizes for

ROLLPINS seem to find new cost-saving uses almost daily. The 9 examples pictured below—where ROLLPINS are shown replacing 9 types of fasteners—only begin to indicate ROLLPIN's wide areas of usefulness. We know of dozens of variations of the nine uses shown. You must certainly know some, too. So tell us yours—it could be a winner!

P.S. If you aren't now using ROLLPINS these 9 examples may give you some useful ideas. So why not write for a generous sample assortment of ROLLPINS and complete information. Dept. R61-64.

REPLACING A SET SCREW . . . a short length Rollpin is self-REPLACING A HEADED PIN . . . in this hinge pin applica-tion, constant spring tension holds Rollpin REPLACING A GROOVED PIN . . . here Rollpin serves as a stop pin. Its light weight and shear retained in the handle of an automobile weight and shear strength function perbrake. Is readily driven into over-drilled hole firmly in place . . . eliminates loosening fectly . . . cuts assembly costs. in shaft for easy of hinge due to wear. removal. REPLACING A HUB ON A GEAR... Rollpin, self-retained in shaft, REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for REPLACING A CLEVIS is simply snapped in-to molded slot to position sintered gear. Rollpin's shear strength is particularly valuable here. PIN . . . here Rollpin holds firmly in clevis, permits free action of the sparkwheel of a cigarette lighter. No riveting or threading moving member. necessary. Faster REPLACING A BOLT AND NUT... Rollpins act as fasteners and pivots ... may also be used with a free REPLACING TAPER REPLACING A COTTER PINS...Rollpin eliminates cost of taper pin reamers and the PIN . . . Rollpin as-sembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily reentire reaming opera-tion. Rollpin costs less fit in outer or inner members depending fit. Easily than a taper pin and installation is cheaper. upon product design requirements.

APPLICATION IDEA

the winners!



transistor radios for the 25 best new ideas!

Win one of these Sylvania portable transistor sets complete with deluxe carrying case.

Your ROLLPIN application could be a winner!

Because design and production engineers are constantly on the lookout for new solutions to problems—and are constantly finding them—we've decided to go to you as the best source of new ROLLPIN application ideas.

You may have hit on a ROLLPIN application that has been extremely helpful to you —one that might spark ideas for others, too. So why not tell us about it and maybe win an extremely useful prize to boot?

Just do this. On the attached official entry form rough out a little sketch of your application on the graph section provided. Alongside it, write a brief description of the application and its advantages for you. Try to keep it to 25 words or so—to make matters a little easier for our judges. Judges will be our own ROLLPIN design staff. They will select the 25 entries that they feel open up the widest areas for new ROLLPIN applications, or that are most ingenious and novel.

Official Entry Form

				1	

Use this form to make a sketch of your ROLLPIN application idea and for a brief 25 or 30 word description. If you wish you may attach a print, but it is necessary to complete this form to enter. Entries cannot be returned, and the judges' decisions will be final. Entries must be postmarked no later than July 15th, 1961 to be eligible. Winners will be notified.

Company

Title____

All entries become the property of ESNA and may be used at any time by ESNA without compensation to the contestant. This affer is not made in any state in which it would be illegal, and is not open to employees, representatives or agents of ESNA.

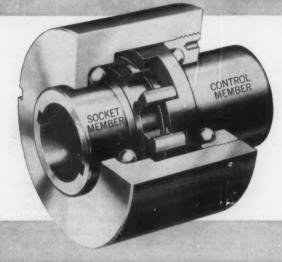


ELASTIC STOP NUT CORPORATION OF AMERICA

P.O. Box 1516, Union, New Jersey



NOW! a positive positioning device that stops feedback torque without backlash...



Rev-Lok devices can efficiently perform a number of application functions such as two-directional drive, positioning, over-running, backstopping, prevention of feedback, etc. Generally, the mounting arrangement used determines which functions are obtained. However, to provide specific details on how Rev-Lok components operate to perform individual functions, sketches and description relating to several typical applications are provided on the facing page.

Now! For any application requiring a power transmission device, that will drive in both directions and instantly stop all feedback torque, the REV-LOK design offers precision performance characteristics and safety factors previously unobtainable in so compact a product.

REV-LOK features a complement of sprags arranged in opposing pairs to automatically and instantly stop feedback in both directions of rotation... there is no backlash on output shaft. Also, the design concept provides multicontact surfaces for greater driving and holding torque, assures equalized radial loading of REV-LOK devices, and evenly distributes wear over all sprags and entire race surface to secure longer life.

The functional versatility of the REV-LOK device is evidenced in its successful use on many diverse applications. Depending on the mounting arrangement employed, REV-LOK devices can be used for: two-directional drive and positive positioning, two-way overrunning or backstopping, dual drive or single revolution applications, anti-shock steering, torque limiting, etc.

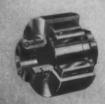
REV-LOK devices have greater torque capacity for their size and weight, and permit higher over-running speeds than any similar product. Current catalog models are available in torque ratings from 90 lbs. in. to 30,000 lbs. in. and with bore diameters ranging from ½" to 2½". Send for your free REV-LOK catalog—it provides further operational and technical details.



FORMSPRAG COMPANY

23606 Hoover Road, Dept. 115, Warren (Detroit), Michigan

Representation Throughout The World • Precision Power Transmission Products

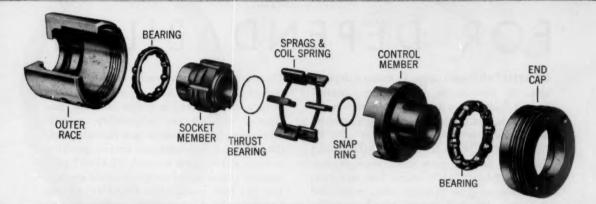


OTHER FORMSPRAG. PRODUCTS

Rawson® Centrifugal Clutches for no-load motor starts and cushioned starting of loads. Formsprage Clutches for every over-running, indexing and backstopping application.



this is REVILOK

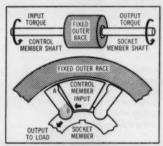


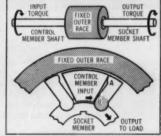
HERE'S HOW REVILOK DEVICES FUNCTION

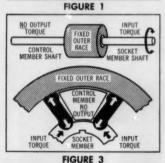
With the OUTER RACE held in a stationary or fixed position, torque is transmitted as follows: (Figure 1) The CONTROL MEMBER projects between each pair of opposing sprags and when driving torque is applied to it, each projection first contacts a sprag at point"A"to disengage the sprag from the OUTER RACE. Then, the CONTROL MEMBER drives against the sprag at point "B" to transmit driving torque directly to the SOCKET MEMBER. (Figure 2) When input torque is reversed, the CONTROL MEMBER rotates a maximum of 3° to release the opposing set of sprags and then again drives the SOCKET MEMBER through point "B" on these sprags. (Figure 3) Any input torque from the SOCKET MEMBER is instantly stopped by the wedging of sprags between the fixed OUTER RACE and the SOCKET MEMBER-feedback torque never reaches the CONTROL MEMBER.

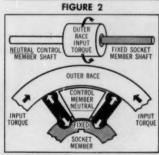
(Figure 4) When the SOCKET MEMBER is held stationary and the CONTROL MEMBER is held in a neutral position between the sprags, any input torque applied to the OUTER RACE is instantly stopped by the wedging of the sprags between OUTER RACE and fixed SOCKET MEMBER. However, by applying a relative torque to the CONTROL MEM-BER in one direction (Figure 5), the OUTER RACE can over-run in the opposite direction and will also be backstopped. To reverse the direction of OUTER RACE over-running and backstopping, the torque applied to the CONTROL MEMBER is reversed.

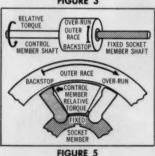
(Figure 6) If the CONTROL MEMBER is held in a fixed position and the SOCKET MEMBER is allowed to float freely on a shaft, the OUTER RACE will over-run in either direction. However, if a torque is applied to the SOCKET MEMBER, the OUTER RACE will only over-run in the direction that the torque is applied and will backstop in the opposite direction.

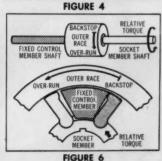












GRAPHITAR

(CARBON-GRAPHITE)

FOR DEPENDABILITY

GRAPHITAR'S own character makes it dependable. A non-metallic engineering material, formed from carbon and graphite powders and a special binder, compacted under high pressures and furnaced at temperatures up to 4,500°F., GRAPHITAR possesses inherent characteristics that give finished parts exceptional dependability. GRAPHITAR'S natural heat resistance, for example, gives bearings, seals, vanes and rings exceptional dependability whenever dependability is one of the prime requisites.

There are other characteristics every bit as important to GRAPHITAR'S dependability. They include chemical and magnetic inertness, mechanical strength and adaptability to self-lubrication. Besides these natural characteristics, GRAPHITAR engineers can control porosity, strength and hardness to match GRAPHITAR'S physical properties to each individual application. It's little wonder that GRAPHITAR has become one of the design engineer's most versatile and useful materials.

In this laboratory test stand, oxidation-resistant GRAPHITAR parts are being checked under simulated operating conditions. Similar tests have proven that, when GRAPHITAR parts are exposed in oxidizing atmospheres at 1,200°F., they show only a weight loss of less than six percent after 200 hours.



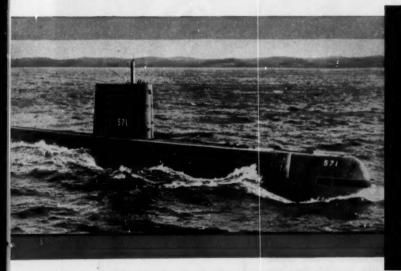


With the aid of photomicrographs, engineers at The United States Graphite Company gain valuable information about the microstructure of GRAPHITAR parts. Modern laboratory equipment such as the Mecallograph enables engineering personnel to advance product quality for maximum dependability. Extensive and continuing R&D work has always been an integral part of The United States Graphite Company's operations.



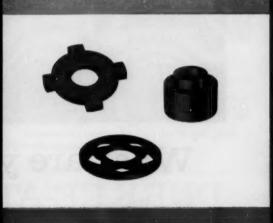


GRAPHITAR air/oil seals employed in today's highspeed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.



GRAPHITAR bearings in the power reactor pumps of American nuclear submarines have compiled an outstanding record for dependability.

Do you have an application in which GRAPHITAR'S dependability can help solve a tough problem, reduce your costs and improve the operational life of your products? Our engineering staff can help you find out. Our field men can also give specialized, on-the-job consultation. Send for your free copy of Engineering Bulletin #20. Included is helpful information about the properties, characteristics and applications of GRAPHITAR.



Unusually shaped parts of GRAPHITAR can be molded easily with today's modern techniques. Ears, face slots and outside diameter notches of friction disc above, left, were molded in one operation without need for secondary machining and finishing.



THE UNITED STATES GRAPHITE COMPANY



DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



What are your V-Belt needs? DURKEE-ATWOOD solves them!

When you buy V-Belts, you want full-rated power transmission, consistent performance and long, trouble-free life. Power drive problems vary from industry to industry and machine to machine, whether OEM or replacement. Durkee-Atwood can meet any of your V-Belt needs with the right belt, a belt made with the newest high tenacity fibres, carefully engineered and thoroughly tested for performance. For any of your V-Belt needs, or for drive design assistance, contact your nearest Durkee-Atwood distributor or factory representative. Or write direct to Industrial Division, Durkee-Atwood Company, Minneapolis 13, Minn.

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Industry's most

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Shield Multiple V-Belts
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Double V-Belts • FHP VBelts • Open End V-Belting • Railroad Belting
Sturdy-Link Belting.



Look for the DA On Your V-Belts

REE-ATWOOD V-BELT

DURKEE-ATWOOD COMPANY

MINNEAPOLIS 13, MINNESOTA

Quick, easy way to get full information on SPS fasteners

Alloy or stainless . . . normal or critical application . . . there is an UNBRAKO socket head cap screw to meet virtually any need. Incorporating the most recent design advances, these cap screws are standard with UNBRAKO. Specify them for high reliability.

All Unbrako High Torque Set Screws, regardless of point type or locking method, have tightening torques as much as 40% higher than those for ordinary set screws, thanks to deeper sockets, fully formed threads, and precision heat treatment to eliminate brittleness and decarburization.

The simple answer to all locknut needs, Flexloc Self-Locking Nuts are one-piece, all-metal fasteners that lock positively on screws, studs, etc., wherever wrenching stops . . . without aid of wires, lockwashers, cotter pins or non-metallic inserts. For miniaturized assemblies, specify microsize Flexlocs.



UNBRAKO pHd with Hi-Life thread

- pHd head means up to 2¹/₃ times as much holding power
- Hi-Life thread means increased fatigue life up to 100%
 For literature, check

Also stainless UNBRAKOS for corrosion-resistant fastening from -- 300° to 800°F.

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UNBRAKO K 16

- Replaces costly specials in critical applications
- 300% more fatigue life than any other standard cap screw
- Threads rolled and fillet area cold-worked after heat treat



UNBRAKO KS 812

- The only stainless socket screw with certified minimum tensile—125,000 psi
- Made of high-grade austenitic stainless hardened through cold working
- · pHd head, Hi-Life thread

For literature, check

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UNBRAKO Knurled Cup Point

- Self-locking—won't work loose even in poorly tapped holes
- 5 times as vibration resistant as closest competitor
- For quick and permanent location of gears, collars and pulleys on shafts

For literature, check

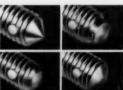


UNBRAKO Plain Cup Point with Nylok®

- Self-locking, whether seated or not, owing to resilient nylon pellet
- For use against shafts too hard for knurled cup point to bite into, or where fine adjustments must be held

For literature, check

*T.M. Reg. U.S. Pat. Off., The Nylok Corp.



Other Unbrako Points

- Cone and half-dog—for permanent location of parts
- Flat and oval—for frequent resetting

To build in a guarantee of locking, order the Nylok feature for all set screws except knurled cup point

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ame		Title			
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ddress	 				
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Full Height FLEXLOC

- High reliability in wide range of uses, especially where high tensile strength is required.
 Also in microsizes
- Like all FLEXLOCS, repeatedly reusable without loss of locking power

For literature, check



FLEXLOC Thin Nut

- 30% lower and lighter than full height nut
- full height nut
 Designed primarily for shear applications
- Meets AN tensile spec for full height locknut



FLEXLOC Clinch Nut

- Quickest, easiest way to put self-locking threaded holes in thin-section materials; invaluable for blind mounting. Also in microsizes
- Knurled shank is pressed through hole in sheet material, then punched, rolled or swaged over

For literature, check

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Company	
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For literature, check

FIRST CLASS

Permit No. 16

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BUSINESS REPLY MAIL

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POSTAGE WILL BE PAID BY

SPS

INDUSTRIAL FASTENER Division

JENKINTOWN 18, PA.



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INDUSTRIAL FASTENER Division

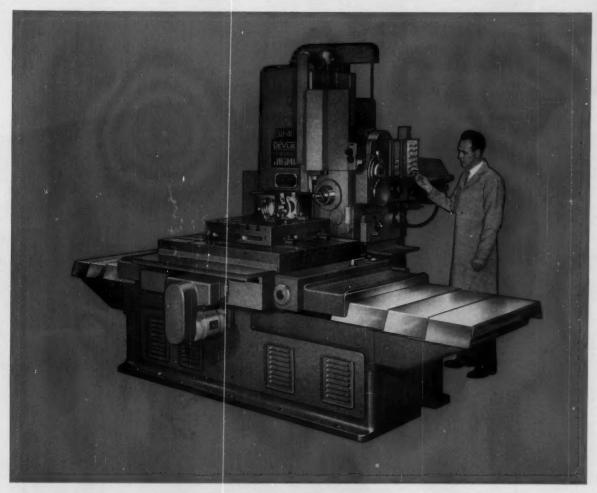
JENKINTOWN 18, PA.



FOR DETAILED INFORMATION ON SPS FASTENERS, SIMPLY FILL IN THE **OPPOSITE** SIDES OF THESE REPLY CARDS AND DROP

IN THE MAIL

STANDARD PRESSED STEEL CO. JENKINTOWN, PA.



DeVlieg selects Bendix Elmag* clutches for trouble-free operation, flexibility

The Bendix Elmag (electromagnetic) friction and tooth type clutches are simple, compact, and easy to install. They have no external shafting mechanism; deliver greater torque than mechanical clutches of the same size.

"We've standardized on Bendix Elmag multiple disc clutches in the bar feed assemblies of our series 'H' Spiramatic Jigmils® for some very good reasons," says Mr. Richard Jerue, DeVlieg Vice President in Charge of Engineering. "The Elmag has always given us smooth, trouble-free performance. And its simplicity gives us flexibility in locating the control where it will be handiest for the operator. The clutch's compactness also permits easy shielding for added protection." Tapecontrolled DeVlieg Jigmils are equipped with a second disc clutch, plus two tooth-type Elmag clutches used on positioning drives.

Because they save space (or provide added torque in the same space), and have less or no idle torque, Bendix Elmag clutches have growing appeal to the design engineer. Give your machine designs these performance advantages—write for complete details.

THIS BENDIX ELMAG CLUTCH EKE 4-S-24 is used in DeVlieg Spiramatic Jigmil. Multiple disc clutches are available in torque capactities of 10 to 16,000 ft.-lbs. (Bendix tooth clutches also available from stock—40 to 4,000 ft.-lb. capacities.)



Bendix-Elmira

fipse Machine Division Elmira, New York





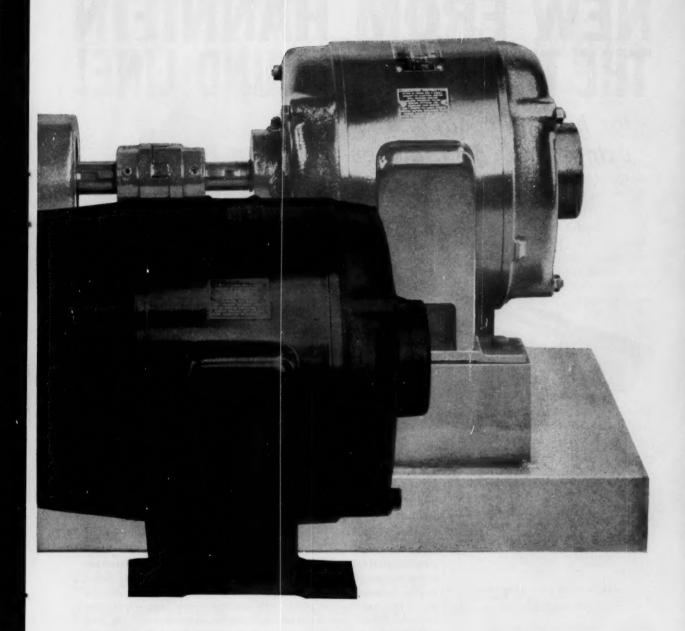
Century close-coupled pump motors

Century close-coupled pump motors make real design sense, especially today when mounting space costs money. The overall length of the pump and motor assembly is considerably shortened—almost 25% in the pumps shown here.

This close-coupled mounting also eliminates the intermediate coupling and bearing. Alignment of pump and motor ceases to be a problem. Maintenance is simplified because there is less to maintain!

Both units shown here are Century 5 horse-power, squirrel cage, open frame construction motors. Both motors are 208-220/440 volts, 3470 RPM.

This standard pump construction measures $33\frac{7}{8}$ long from bedplate base to the end of the



make this difference . . . and more

pump. The close-coupled pump unit measures $25 \frac{1}{2}$ " long. This is a difference of $8 \frac{8}{8}$ " in overall length—a space saving of almost $25 \frac{9}{0}$ in these two comparable horsepower constructions.

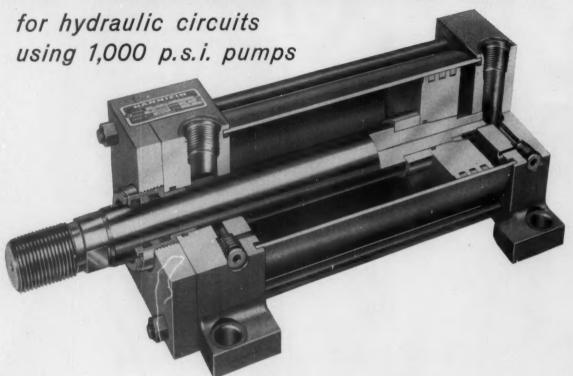
The Century close-coupled pump motor is not a "special." Neither is its price. You can order it directly from Century stock. Your Century representative (he's a full-time motor specialist) or distributor can give you full details on close-coupled pump motors—including prices and delivery time. Contact him right away, and write for Bulletin 1455 to:

CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri Offices and Stock Points in Principal Cities



NEW FROM HANNIFINTHE THOUSAND POUND LINE!



- A true hydraulic cylinder
 not a modified air cylinder
- Offered in nine bore sizes
 1" through 8"
- Every model withstands at least 1,000 p.s.i. in every bore size
- Built to save you money yet not "built to a price"

Now, for the first time in hydraulic cylinder manufacture, Hannifin offers a top quality cylinder tailored to the medium-high-pressure hydraulic circuits you operate off 1,000 p.s.i. pumps.

Series "L," the "Thousand Pound Line," is NOT a modified heavy duty air cylinder. It is built for the job... with steel heads and steel barrel for full compliance with J.I.C. hydraulic recommendations. Other extraquality features include an induction hardened and hard chrome plated rod, nodular iron piston with cast-iron piston rings — leakproof "Lipseals"," optional — longer cushions on cushioned models, and the Hannifin-developed bronze cartridge gland with both "Lipseals" and "Wiperseal" to keep the rod drip-free. S.A.E. straight thread "O" ring ports as recommended by J.I.C. are optional at no extra cost just as they are in the Hannifin heavy duty Series "H" hydraulic cylinder.

Parker-Hannifin field engineering service can help you meet your needs precisely, help you select the proper Hannifin cylinder for any service, air or hydraulic. Call your nearest Parker-Hannifin sales office or write direct for our new bulletin giving all dimensions of Hannifin Series "L" cylinders.



HANNIFIN COMPANY

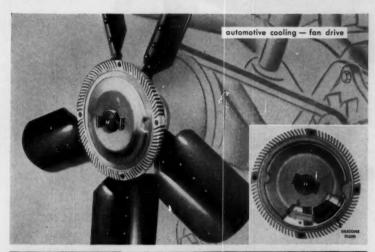
A DIVISION

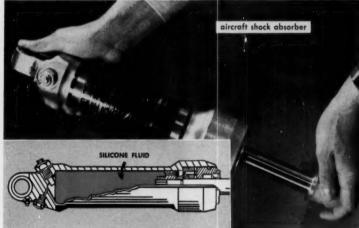
515 South Wolf Road . Des Plaines, Illinois

EUROPEAN DIVISION - PARKER-HANNIFIN N. V. - SCHIPHOL - THE NETHERLANDS

3077-PH

How To Improve Designs





Silicone fluids let you forget time -- temperature

Design more efficient mechano-fluid devices. Assure reliable, uniform performance. Do both with Dow Corning silicone fluids.

Silicone fluids let you forget time because they are resistant to oxidation . . . are nongumming and nonsludging. Silicone fluids let you forget temperature because they maintain a near-constant viscosity, regardless of whether operating environment be hot or cold . . . are serviceable at temperatures as low as minus 100 F; at temperatures as high as 400 F.

Furthermore, silicone fluids are highly resistant to breakdown due to shear; are noncorrosive.

These are the reasons silicone fluids make, possible design changes impractical with other fluids . . . help improve damping devices, fluid couplings, liquid springs and hydraulic power drives. Here are two typical examples:

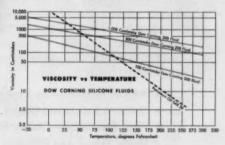
Unimpaired Drive Action

The Visco-Drive assembly shown opposite, designed and manufactured by Eaton Manufacturing Company, automatically slows automotive engine fans at high speeds when cooling is least needed . . . conserves horse-power and reduces noise.

Eaton engineers specify Dow Corning silicone fluid as the drive medium to assure uniform driving action over long periods of time under widely differing conditions.

Soaks Up Shock

Another example is an aircraft shock absorber manufactured by Cleveland Pneumatic Tool Company. Because the Dow Corning silicone fluid used in this liquid spring is much more compressible than other liquids, designers were able to reduce size of the oil chamber by 30%, thus saving vital weight and space.



Learn how other designers are putting to advantage the unusual combination of properties available only in silicone fluids. Send today for descriptive brochure. Address Dept. 6918a.

Your best source for technical assistance in adapting silicones to your products is the Dow Corning office nearest you.



Dow Corning CORPORATION

MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.



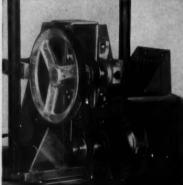
New R/M CX* MOLDED V-Belts Outlast Others 8 to 1!

Other notched belts are cut at the sides...leave components exposed to atmosphere and permit separation, costly wear on sheave grooves. CX V-Belt is the *only* fully *molded*...fully *jacketed* notched V-belt. This exclusive R/M development provides drive design and performance advantages not possible with conventional belts.

- No Cut Notches—No Exposed Sides—No Separation
- Quieter, Smoother, Cooler Running
- High Flexibility—Resists Flex-Cracking
- Holds Shape and Effective Length
- Micro-positioned Power Arch Strength Member
- Vibrationless—No Slap, No Hum, No Buzz
- Longer Drive Life

Talk to R/M transmission specialists about new CX V-belts or other R/M belts for every drive application.

*Patented, made for original equipment



The only fully molded, fully jacketed, notched V-belt made. Available in many sizes for a wide range of design requirements. Write for Bulletin M220.



for

RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION . PASSAIC, N. J.

ENGINEERED RUBBER PRODUCTS

UNLIMITED MANIFOLD MOUNTING OF VERSA SERIES "A" SOLENOID VALVES



ainates

Now...You can mount an unlimited number of Versa Series "A" Solenoid Valves as one integrated unit with these new Versa Co-Ordinate Assemblies. These versatile assemblies make possible simplicity of design in both Hydraulic and Pneumatic operation, because only one inlet is required to feed the entire line of valves, and where threaded exhaust block is used, only one exhaust connection need be made. They are so versatile that additional blocks can be added at any time and so compatible that blocks with and without adjustable built-in bleed controls can be used

together in one unit. The Versa Series "A" Solenoid Valves used with this assembly are the largest capacity valves for their size. These four-way valves have a full 3/16" diameter flow area and measure only 1%" in diameter. Combined with Versa "A" Valves these Co-Ordinates provide the most flexible and reliable Multiple Solenoid Valve Assemblies in the Hydraulic and Pneumatic Control Valve field. ■ Co-Ordinates are available from authorized Versa Distributors throughout the world. Write for Bulletin #960.



VERSA PRODUCTS COMPANY, INC. 150-M Coolidge Avenue, Englewood, New Jersey

FOR YOUR DESIGN ...

The Power-Take-Off most users specify...



Twin Disc Friction and Fluid PTO's — the world's most complete line

STANDARD FRICTION PTO



Easy-to-mount unit consisting of clutch PTO assembly with shaft and bearings in a rigid cast iron housing. Designed for manual operation on all internal combustion engines with standard SAE flywheel housings from No. 6 to No. 00. Triple-plate 14" to 21"; double-plate 11½" to 24"; single-plate 6½" to 24". Twenty models with horsepower capacities to 600 hp and torque capacities to 6730 lbs.-ft.

"LIMITED ATTENDANCE" FRICTION PTO



A modified version of the standard Twin Disc PTO. Features a new clutch engagement mechanism that virtually eliminates throw-out collar wear, ends daily greasing for good. In ailfield pumping jack service this PTO will quickly pay for itself in labor savings alone because it needs greasing only twice a year. Available in 10", 11", 14", and 18" sizes. Conversion kits for older PTO's also available.

NEW "HIGH-ENERGY, HIGH-SPEED" PTO



A recent Twin Disc development for engines developing 300 to 500 hp at speeds up to 3380 rpm. Designated Model IBF-214P, it has a unique ventilated center plate that permits air flow to dissipate excess heat. An amazing ability to withstand high-energy loads makes this PTO well suited to applications where equipment is subject to heavy starting loads. Tapered roller bearing is continuously lubricated with oil. Improved throw-out collar design permits extending greasing periods up to six months.

AIR-OPERATED PTO



A new series combining the convenience of Model PO Air Clutches with the time-tested dependability of Twin Disc Friction PTO's. Ideal for drilling rigs where the operator must work from a remote driller's platform. A touch on a control valve handle engages and disengages the clutch... provides "torque without effort." Normally requires only 90 psi air pressure. Capacities to 600 hp. Conversion kits available.

FLUID PTO (Model HU)



Used on constant-speed, constant-torque drives where efficiency of 95% or better is desired. Consists of a fluid coupling combined with a cast belousing, bearings and output shaft. In oilfield pumping installations, Model HU improves engine operation by reducing variation in engine rpm per stroke by as much as 50%. Also cuts engine vacuum variation for lower BMEP. Sizes: 14.5, 17.5 and 21.

DISCONNECTING FLUID PTO (Model HUD)



Disconnects power source from driven equipment to reduce impact shocks 70% or more. Eliminates "engine fighting" to assure balanced distribution on compounds. Life of chains, clutches and other running parts is almost doubled. Isolation of torsional vibrations and elimination of slow-speed lugging saves wear and tear on engine. Furnished with 21" or 27" double-circuit fluid couplings for engines with #0 and #00 housings in the 100 to 600 hp range.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin . HYDRAULIC DIVISION, Rockford, Illinois



Modern board-lift forging hammer

By designing front-end spindles to be forged, automobile and truck manufacturers practically eliminate danger of failure of these vital parts, even under sudden turning stress that can reach thousands of foot-pounds.

Start your designs by planning to use forgings everywhere there's a high degree of stress, vibration, shock, or wear. Forged parts withstand them all better than parts made by other fabrication methods. And forgings have no hidden voids to be uncovered after costly machining hours have been invested ... the hammer blows or high pressures of the forging process compact the better forging metal, make it even better.

Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED



Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magnets



Upsetting of the hexagonal section in the center of this adjusting screw cut finished cost 28% compared to that hogged from hexagonal stock. The finished forging is stronger, too...upsetting increases strength by directioning the metal grain flow to match the shape of the part.

Check your products for parts that might be upset forged . . . then call -



CLEVELAND 5, OHIO . EAST CHICAGO, INDIANA . T. P. CHAMPION, President

When its a vital part, better make it FORGED



Aeroquip Expands Its Tube Fitting Line . . .



Aeroquip now offers 58 different styles of tube fittings for all hydraulic and pneumatic circuits and other fluid systems. This greatly expanded line includes elbows, tees, crosses, straights, union swivels, reducers, plugs and caps in sizes for ¼ " to 3" lines. Thread types include J. I. C., P. T. T., S. A. E. straight thread boss and NPTF pipe ends.

to Provide Industry's Most Complete Range of Products for Fluid Piping Systems



OVER 60 HOSE TYPES

To convey steam, chemicals, hydraulics, fuels, air, hot water and other fluids, Aeroquip produces over 60 different hose types with cotton braid, single wire braid, multiple wire braid and wire wrap reinforcing for pressures up to 5000 psi. Inner tubes are made of Teflon or synthetic rubber. Aeroquip Hose and Reusable Fittings are available in sizes from 1/8 " up to 7" diameters.

COUPLINGS UNLIMITED

For quick connection and disconnection of fluid lines, use Aeroquip Self-Sealing Couplings. Aeroquip can provide the coupling to meet your function and size requirements, from miniaturized quick-disconnect couplings up to 12" cargo transfer couplings.



AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA • AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Teflon is DuPont's trade name for its Tetrafluoroethylene resin.

DESIGN PROTOTYPE PRODUCTION FIELD SERVICE SERVICE PARTS

PROTOTYPE ASSISTANCE

Checking fluid piping performance on equipment prototypes is an important part of the complete Aeroquip Fluid Piping Service for manufacturers.

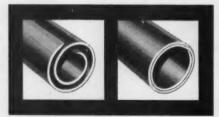


Bundy can mass-fabricate practically anything

Almost any tubing component you may need—simple or complex—can be mass-fabricated by Bundy. If you are planning a new product, Bundy specialists will work with you at any

time to iron out kinks in tubing problems. Or perhaps Bundy engineers can help you simplify the design—and cut costs—of existing tubing components. And when you specify Bundy you get superior tubing. Bundy-

weld meets ASTM 254; Government Specification MIL-T-3520, Type III. Phone, write or wire: Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight, uniformly smooth and easily fabricated...has remarkably high bursting and fatigue strengths. Sizes up to 5%" O.D.

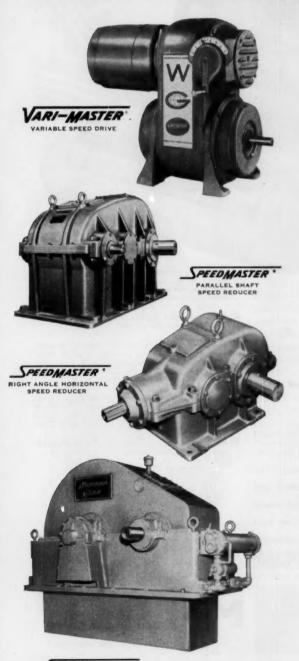
BUNDY TUBING COMPANY

DETROIT 14, MICH. . WINCHESTER, KY. . HOMETOWN, PA.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN.



POWER TRANSMISSION REQUIREMENTS?



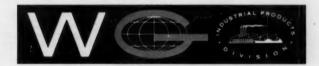
Just name them!

Western Gear Corporation's line of catalog products in the power transmission field is second to none in quality and reliability.

Three great names fill out the Western Gear line... StraitLine®, SpeedMaster® and Vari-Master®. They have earned a first-rate reputation in all industries using power transmission equipment by providing users and manufacturers these guarantees!

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- . long life and reliable operation
- easy maintenance
- · standardization of parts and high interchangeability

Whatever your power transmission requirements might be, Western Gear can supply them from stock or engineer them to your exact specifications. Want to know more? Use the coupon below or phone. And always remember...



on the long run . . . QUALITY COSTS YOU LESS!

NAME		Please send catalogs checked below: StraitLine Speed Reducers Bulletin 5816 StraitLine Gearmotors Bulletin 5806 SpeedMaster Parallel Shaft Bulletin SpeedMaster High Speed Bulletin Vari-Master Variable Speed Bulletin 6107
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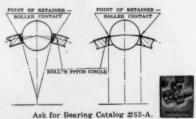


INCREASE EXPECTED LIFE UP TO 10 TIMES!

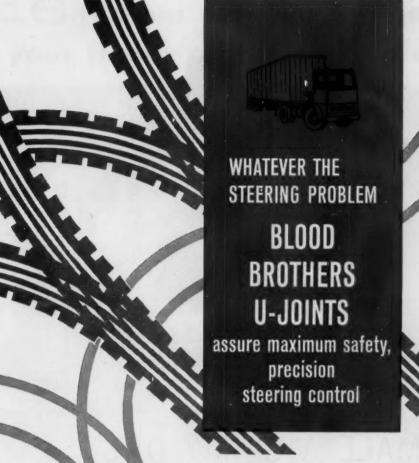
You need CAGEROL bearing performance if higher speeds and increased misalignment have prevented the utilization of needle bearing load capacity in your applications. Most important, CAGEROL bearings can deliver up to 10 times more expected life where misalignment and increased speeds exceed the capabilities of ordinary and guided needle bearings. The difference is in the exclusive McGill construction that features tapered retainer pockets for balanced roller guidance, crowned rollers, and black oxide retainer finish. CAGEROL bearings are interchangeable with all heavy duty needle roller bearings - with or without inners in two bore sizes.

> McGILL MANUFACTURING CO., INC., Bearing Division 200 N. Lafayette Street, Valparaiso, Indiana

- tronically gauged to insure precision contour and size uniformity. Relieved ends assure even load distribution.
- 2 Flat ends fully engage integral race shoulders. provide maximum support.
- 3 Proper guidance assured by tapered retainer pockets. The design insures balanced roller support and eliminates corner wear from edge loading of straight pockets where retainer OD and pitch circle are coincident.
- Simultaneously punched pockets assure accuracy of race and roller alignment. The black ferrous oxide retainer finish absorbs and retains lubrication, reducing the friction coefficient.
- SAE 52100 steel outer race has optimum hardness and surface finish.



engineered electrical products precision needle roller bearings



Nearly all major truck manufacturers rely on the ingenuity, ability and established leadership of Rockwell-Standard engineers to provide Blood Brothers universal joints for today's increasingly complex steering assemblies. With each new steering advancement Rockwell-Standard engineers have demonstrated their resourcefulness and skill by supplying dependable, trouble-free universal joints.

For example, the development of power steering and tilt cab trucks introduced the need for more intricate steering shaft assemblies. Rockwell-Standard engineers met the challenge with universal joints capable of transmitting power around corners without any sacrifice in operating performance or steering safety.

PARTICULARLY IMPORTANT IS THE ROCKWELL-STANDARD DEVELOPMENT OF:

- An anti-backlash universal joint for steering columns that provides greater precision in steering control.
- A specially designed machine that tests every Blood Brothers steering joint at 4000-inch pounds of torque. This pre-shipment precaution insures dependable steering that cannot fail even under extreme torque pressure.

Whatever the steering assembly, whatever problems it presents, Rockwell-Standard engineers can design and develop universal joints that are reliable, efficient and economical.



Universal Joint Division, Allegan, Michigan





SMALL A.C. MOTORS

Consider the many advantages of using Globe precision miniature a.c. motors. The small sampling of electric motors above ranges from $1.07^{\prime\prime}$ to $1.675^{\prime\prime}$ in diameter; torques range to 4.5 ounce inches continuous duty (up to 200 inch pounds with a Globe planetary gear reducer). A new $3\%^{\prime\prime}_6$ diameter motor has been designed for larger applications.

They are available in induction and hysteresis-synchronous types, 60 or 400 cycles or for variable frequency operation. Universal a.c./d.c. motors are available in 15% and 21% frame sizes. Most sizes and types are stocked by Globe for quick prototype delivery, some within 24 hours!

Right now Globe is developing commercial versions of our missile-quality motors. Performance is the same but the cost is engineered out by relaxing environmental requirements. One such motor goes in automatic telephone switching equipment. Another is in a vending machine. There are dozens of others. In these kinds of applications it is essential to have a motor of high reliability, long life, small size, freedom from maintenance, and modest price.

Get in touch with Globe early in the design stage. Very probably Globe has already made a motor close to your requirements. You'll receive a recommendation for your specific job. Please request catalog ACS from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, GYROS. STEPPERS. BLOWERS, MOTORIZED DEVICES



116 reasons why we can help you put your finger on the right plastic faster







16 grades of Vulcanized Fibre...



3 thermoplastics-nylon, DELRIN,* PENTON



12 grades for printed circuits...

This will give you an idea of how surely National can help you pinpoint exactly the plastic you want. National has the broadest line in the industry, including standard forms, precision - fabricated parts, and a huge stock of many grades ready for immediate shipment. For

fast help, samples, or more information, contact your nearby NVF sales office. You'll find the 'phone number in Sweet's Product Design File 2b/Na. Or write NVF, Dept. TT, Wilmington, Del. It's a direct line to the one best material per dollar of design performance.



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BTR[®] Elastomeric Mountings

the answer to high reliability for sensitive instruments, guidance systems, electronic equipment

Are you concerned with high reliability for equipment with low vibration/shock tolerance? Is your application on aircraft, missiles, space craft or ground support equipment?

Then here's the vibration isolator that gives you everything you need.

LORD BTR (Broad Temperature Range) Elastomeric Mountings cushion high G shock loads, isolate vibration to 2000 cps, give all-attitude protection, limit resonant amplification to approximately three or less. And this performance is unaffected by extreme environments and temperatures from -65° to $+300^{\circ}$ F. Size for size, ounce for ounce, they pack more load-carrying and energy-storage capacity than any other isolator.

Performance has been repeatedly proved on the most difficult applications. Even ultra-sensitive inertial guidance systems on operational ICBM's are now protected by *standard* production BTR Mountings.

Utilize this advance in vibration/shock/noise control to achieve higher reliability for your project.

Information on BTR Elastomeric Mountings is contained in Bulletin 301, available from your nearest LORD Field Engineering Office or the Home Office, Erie, Pa.



FIELD ENGINEERING OFFICES

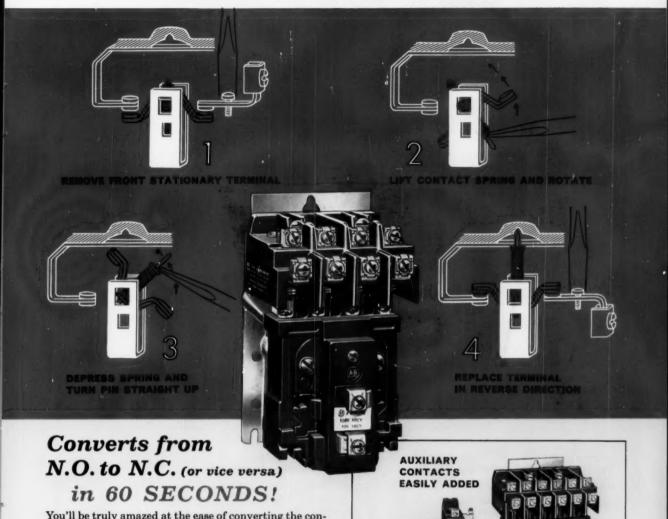
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"In Canada — Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

Four simple steps (AB) to contact changeover

Total time-not more than 60 seconds



You'll be truly amazed at the ease of converting the contacts on these Allen-Bradley Bulletin 700 Type BR relays. Using only a screwdriver, as shown above, the contacts can be changed from N.O. to N.C. (or vice versa) in four easy steps—that take only 60 seconds: Such convenient flexibility is a "natural" for reducing relay inventories.

The Type BR relays are built to provide many millions of trouble free operations. With the built-in permanent air gap, magnetic sticking is impossible. And the molded coil is impervious to all harmful atmospheres. Of course, the double break, silver contacts never need attention. If you use relays, there are money savings for you in the Type BR relay line!





Type BR relays are available with 2, 3, 4, or 6 poles but as a valuable bonus, one or two fully rated poles can be added to the base of each relay—even in the field. It's a simple addition that takes only moments.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL BE SURE YOU GET



Quality Appearance Quality Operation

Specify Allen-Bradley's line of OILTIGHT CONTROL STATIONS

Allen-Bradley oiltight units and stations harmonize with the trim lines of modern machine tools—they look as if they were a part of the machine. Also, from the wide selection of control units, you'll be able to satisfy every operating require-

ment. A-B control units are positively oiltight—impossible for oils and cutting fluids to foul the contacts. And the silver contacts assure reliable operation. The rugged construction and generous wiring room of all A-B stations are valued by the installation engineer. Insist on Allen-Bradley pilot control units and stations—you can't make a mistake! Send for Publication 6090.



push button, also made with extended head, button and selector



PUSH-TO-TEST
PILOT LIGHT
ush Six different color lenses available.



4-WAY SELECTOR
SWITCH
Also furnished for



PILOT LIGHT
Transformer or full voltage types.



Has 2 N.O. or 2 N.C. sets of contacts.



Four lights of different colors in one unit.



SWITCH
With coin slot operator. Other operators available.



CONVENIENCE RECEPTACLE For plugging in work light or

SPECIAL CONTROL CONSOLES

can be furnished to meet your exact operating requirements.

SIX-UNIT CONTROL STATION

in die cast aluminum housing. Also made with up to 4 vertical rows with 4 units per row.



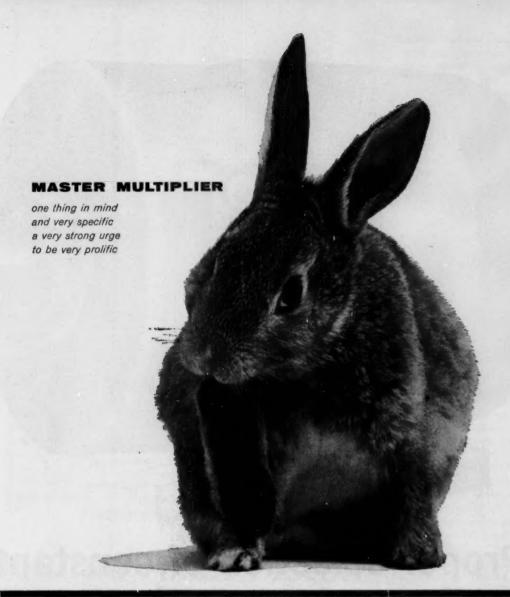
5-61-RM

ALLEN-BRADLEY

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Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. . It Canada: Allen-Bradley Canada Lid., Galt, Ont.

QUALITY MOTOR CONTROL



In our humble opinion, Brer Rabbit's reputation as a multiplier is vastly overblown. Compared to Printmaster



900 he's strictly single-track. Brother Rabbit can reproduce only himself. Printmaster 900 will process any dry diazo material up to 42" wide. In one pass. Without sticking. And at speeds up to 75 feet per minute. More: "900" offers a major advance in whiteprinting—new, sleeveless, scratch-proof developing, exclusive with Ozalid. No slip sheets. No sealing sleeve. Further, no costly electron tubes. And no—comptrollers please note—no heavy investment. All Ozalid Whiteprinters can be bought, leased or rented without tying up capital. Like the full, dollar-saving story on "900"? Write today.

Printmaster 900. Big reproducer at top speed. Heavy duty, dry developing whiteprinter. Height: 701/2"; Width: 841/4"; Depth: 461/2". Simple, dependable, economical.

Remember: for best results from Ozalid Whiteprinters use Ozalid Paper and Ozalid Supplies...we repeat; use Ozalid Paper and Ozalid Supplies.



	James A. Travis, Mgr. Marketing alid, Dept. 213, Johnson City, N. Y.	
Ple	ase send more information on cost-cutti	ne
Pri	ntmaster 900.	
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Ad	dress	_
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Proper selection of constant Hydraulic Pumps for systems

By: Ellis H. Born

Director of Sales-Engineering

Denison Engineering Division

American Brake Shoe Co.

Columbus, Ohio

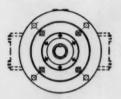
Whether to use a high pressure system or a low pressure system is perhaps the most basic decision the designer faces in developing the proper hydraulic system. This decision involves such factors as efficiency, space requirements and, most important, cost.

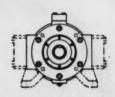
SPACE CONSIDERATIONS

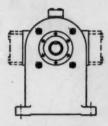
Furnishing fluid horsepower is the function of a hydraulic system. Horsepower yield is determined by multiplying system pressure (psi) times flow rate (gpm) times a constant of 0.000583. Application of this formula reveals that a 5000 psi system develops five times the horsepower of a 1000 psi system at the same rate of flow. Accordingly, the 5000 psi system requires only 20% of the flow rate of a 1000 psi system to produce the same fluid horsepower.

Reduced rate of flow permits designs which incorporate smaller valves, piping, hydraulic cylinders and reservoirs. Since reservoirs are often the largest single fluid component in a system, appreciable space savings can be realized with high pressure systems. If recommended hydraulic practice is followed, reservoir capacity is three times greater than the gpm displacement of the pump. Hence, for the same amount of fluid horsepower, reservoir capacity can be reduced as much as 80% in a high pressure system. The high

MOUNTINGS







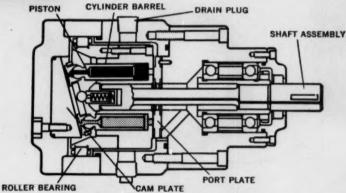
FLANGE

FACE and PEDESTAL

BRACKET



Denison constant volume axial piston pumps offer volumes up to 122 gpm, pressures to 5000 psi, at their rated speeds of 1200 and 1800 rpm. Face, flange, bracket or pedestal mountings are available for ready adaptation to your particular installation. Models are available for either clockwise or counter-clockwise rotation.



volume Axial Piston up to 5000 psi

DETAILS OF CONSTRUCTION

pressure system not only allows savings in space through use of smaller components and capacities, but reduces the weight and mass of the hydraulic power package as well.

COST FACTORS

Use of smaller components in high pressure systems not only saves space, but affords worthwhile cost reductions.

Compact system elements cost less and because they are smaller, as well as lighter, assembly is easier and faster. Raw material requirements are also reduced. These advantages permit the over-all hydraulic system design to incorporate less weight and mass. The latter is especially important where portability is concerned.

SYSTEM EFFICIENCY

In any hydraulic system, a part of the generated fluid horsepower is used to force fluids through the system. Resultant line and pressure decreases are far less significant in high pressure systems. For example, a pressure drop of 50 psi represents a loss of 5% in a 1000 psi system, but only a 1% loss in a 5000 psi system. It follows that high pressure systems have an inherent efficiency advantage over low pressure systems.

The ability to provide sustained efficient power for a high pressure system is best fulfilled by a precision-built axial piston pump because of its low slippage rate and operating characteristics.

All internal forces created by hydraulic pressure against the moving parts are counteracted by the use of hydraulic balancing.

Using the principle of hydrostatic balancing eliminates the need for expensive and often cumbersome thrust bearings in the pump. This design minimizes pump size and allows a more compact pump or fluid motor package.

Other advantages are gained through hydrostatically balancing pistons and the cylinder barrel. For example, excessive loading of piston shoes against the cam plate is avoided. In addition, excessive loading of the cylinder barrel against the port plate is prevented, virtually eliminating wear caused by sliding action.

Life expectancy of internal axial piston pump parts is almost infinite since constant lubrication is supplied by system fluid.

Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

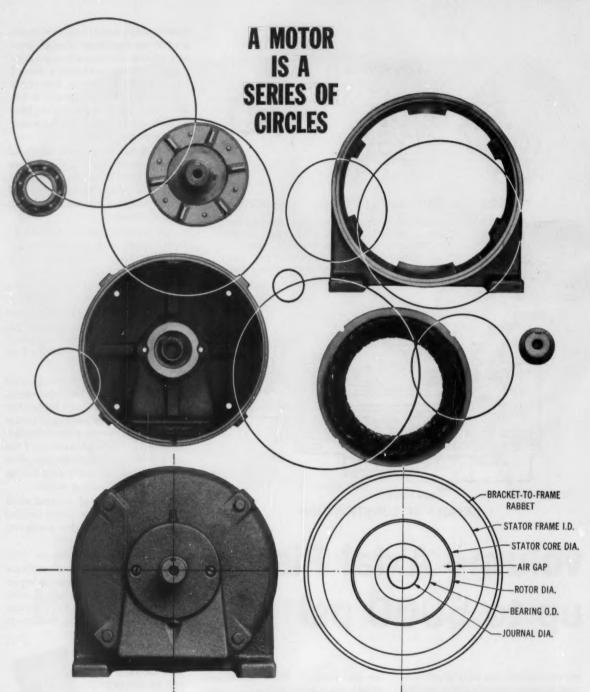
Write for your copy of Bulletin 220-

"Hydraulic Power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

DENISON ENGINEERING DIVISION

American Brake Shoe Company

1240 Dublin Road . Columbus 16, Ohlo



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including [FPA-SEAD epoxy insulation for use where conditions are most severe.



GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio



Revere helps "fit the metal to the job"

AND A PUMP MANUFACTURER FABRICATES
SUPERIOR PARTS WITH GREATER EASE...INCREASES TOOL LIFE

An important part of the submersible pumps made by Tait Manufacturing Company is the brass diffuser casing you see above. This part had formerly been made of ferrous metal. While satisfactory as a pump part it was difficult to work and draw . . . at the same time tool life was short.

One of Revere's Technical Advisors was asked to study the problem. Revere Cartridge Brass Strip of a certain temper was recommended, samples submitted, and, after extensive tests, was approved. The customer has found that not only does the diffuser casing, made of Revere Brass, perform well in the pump, but it also has superior drawing properties, is more easily worked, and tool life has been substantially increased.

This meticulous attention to "fitting the metal to the job" also resulted in Tait Manufacturing Company's specifying Revere seamless leaded brass tubing for the upper body shell of its submersible pumps. Here the application called for extremely close straightness and roundness control which meant special attention to detail on the part of the Revere mills.

Why not put the extensive knowledge of Revere's T.A. Service to work for you? With the wide variety of metals at your disposal, perhaps Revere can help you select the one best suited for the job, with a resultant saving of money while improving product quality.



REVERE COPPER AND BRASS INCORPORATED

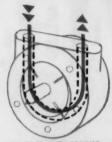
Founded by Paul Revere in 1801 Executive Offices; 230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detrois, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Fort Calboun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

TA STORY COMPRESSORS

AIR MOTORS VACUUM PUMPS

Gast offers you specialized experience in Air Motors, Air Compressors and Vacuum Pumps . . . for original equipment or plant use. The types and sizes shown, with selected accessories, will solve many application problems. All models feature rotary sliding-vane design for quiet, pulseless, positive air displacement. Vanes take up their own wear, maintaining high efficiency.



ALL GAST UNITS FEATURE THIS SIMPLE, DEPENDABLE ROTARY-VANE DESIGN

COMPRESSED AIR MOTORS Hp. At 60 Psig. At 90 Psig. Wt. Lbs. Model Rpm. 0.13 51/2 1,000 2 AM 0.73 8 4 AM 17 6 AM 1,000 0.80 1.30 2.40 25 1.60 BAM 1,000 4.20 65 16 AM

BLACK = LUBRICATED

= OIL-LESS MODELS

AIR COMPRESSORS

						Rec.	Max.	Press.	Psig.		
Model	Model No.	Hp.		Cfm.		Cont. Oper.		Inter- *		Net Wt. ⁴ Lbs.	
Integral (Motor Compressor)	0406 0211 0321 0521	1/12 1/4 1/4 1/3	1/12	0.57 1.3 2.3 3.8	0.5	15 15 20 15	10	20 25 25 20	15	16 22 25 26	16 22
Light-Duty	0240 0440 0740 1550 3040	1/4 1/3 1/3 1/4 2		1.9 4.0 5.9 10.5 30.0	1.9 4.0 5.9 10.5 24.0	10 10 10 10 10	10 10 10 10	20 20 12 15 15	10 10 10 10	8 10 10 29 68	7 9 9 26 60
Heavy-Duty Fan-Cooled	0465 0765 1065 2065 2565 4565	1/2 1/2 1/2 2 5		4.0 5.9 8.3 17.0 21.0 45.0		25 10 25 15 15 15		30 15 30 20 20 20		18 18 33 52 51 92	

*Weight without base or motor, except integral models.

VACUUM PUMPS

						Rec.	Max.	Vac. "	'Hg		
Model	Model No.	Hp.		Cfm:		Cont. Oper.		Inter- mittent		Net Wt. ¹ Lbs.	
(Motor Pump)	0406 0211 0321 0521	1/12 1/4 1/5	1/12	0.57 1.3 2.3 3.8	0.5	15 15 28 28	10	25 27	20	16 22 27 28	16 22
Light-Duty	0240 0440 0740 1550 3040	1/2 1/2		1.9 4.0 5.9 10.5 30.0	1.9 4.0 5.9 10.5 24.0	15 15 10 15 15	20 20 20 20 20 20	26 26 26 25 27	24 24 24 24 25	9 11 11 29 68	10 12 12 30 66
Heavy-Duty Fan-Cooled	0465 0765 1065 2065 2565 4565	1/2 1/2 1 1/2 3		4.0 5.9 8.3 17.0 21.0 50.0		28 28 28 28 28 28 20		28		18 18 33 54 53 92	-

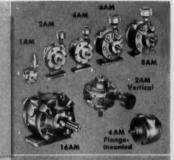
*Weight without base or motor, except integral models.

MINIATURE OIL-LESS . COMPRESSOR . VACUUM

Model	Wt., Lbs.*	Hp.	Type Drive	Pump Rpm.	Cfm.		Max. Vac. " Hg Cont. Oper.
0330	3.2	1/40	direct	3450	.35	10 psig.	20
0630	9.2	1/12	direct	3450	.6	20 psig.	24
1030	9.2	1/12	direct	3450	1.0	10 paig.	20

1/20 TO 7 H.P.

CAST AIR MOTORS are explosion-proof and variable in speed. Built with either right or left-hand rotation—also in reversible models. They are amazingly compact... light in weight for h.p. delivered... and low in cost. They'll start in any position... can't burn out from overloads or stalling. Roter vanes take up their own wear, maintaining "like-new" efficiency. Offered with foot (base) or flange-type mounting... and for horizontal or vertical position.



.6 TO 45 C. F. M.

INTEGRAL MOTOR-PUMPS — Com-pact, light weight, efficient "pack-aged" units. Compressor totor mounted on motor shaft. Pulseless

LIENT DUTY — For intermittent service. Positive displacement. Resemble heavy-duty models, less fars or deep cooling fins (not needed for brief operating periods). Simpler lubricator.

HEAVY BUTY — Fan-cooled for continuous operation. Rotary design — maximum air per lb., per h.p. Automatic lubricator has self shut-



.6 TO 50 C. F. M.

INTEGRAL MOTOR-PUMPS — Compact, light weight units save mounting cost and time. Excellent for portable equipment. Rotor mounted on motor shaft.

LIGHT BUTY - For intermittent service. Quick pick-up, trouble-free performance. Resemble heavy-duty models, less fans or deep cooling fins. Simpler oiler.

HEAVY DUTY - Forced air fantrouble free dependability. Deep cooling fins. Lubricator has built-in automatic shut-off.



.3 TO 1 C.F.M.

MINIATURE OIL-LESS PUMPS (larger oil-less models shown in red above.) 3 typical models shown here. Quality rotary slid-ing-vane construction. Other motors available: 1/25 & 1/20 h.p.



Motors • Vacuum Pumps • Compressors GAST MANUFACTURING CORP.

WRITE TODAY for "Application Ideas" Booklet, Gast Catalog or Model Data Sheets. Our engineers will gladly assist you. "Air may be your Answer!"



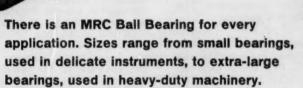
Original Equipment Manufacturers for Over 30 Years

ARLIN-ROCKWELL RELIABILITY OUNTS in Q WALITY POWER TOOLS by Black & Decker.



Black & Decker #11 Heavy Duty Jig-Saw

MRC Ball Bearings have contributed to the reliability of Black & Decker Power Tools for over 25 years.



Backed by 63 Years Experience

Consult OUR Engineering Department on YOUR Bearing Problems



MRC

MARLIN-ROCKWELL CORPORATION

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Dependable Natural Gas Power...





A milestone in public education was reached this year as a Clearwater, Florida school experiment set out to compare air-conditioning operating costs and student achievements. Although building contracts for the new schools were comparable, the air-conditioned school, above, actually cost less to build because design was more compact, with reduced roof and corridor construction. At left, 7th grade science students stay cool and fresh, sustain interest throughout the day in climate controlled classroom.

Florida project relies on International engines to keep operating expense at reasonable level...

A new era for municipal air-conditioning may be the result of a school project getting underway in Clearwater, Florida. It is believed that climate control in the classroom will improve student comfort, promote alertness, reduce illness and absenteeism, and generally upgrade the education of our children. Although industry has universally accepted the merits of air-conditioning, school and municipal officials question its value when confronted with the cost and operating expense of reliable cooling equipment. The Clearwater project will answer this question.

The project began with construction of two junior high schools—the Oak Grove School in Clearwater and the Pinellas Park School in St. Petersburg—each one comparable in cost and capacity. The Clearwater school is air-conditioned, the other is not. Comparison of operating expenses and educational achievements during the 1961-62 season will determine if climate control is worth the extra appropriation.

To keep operating costs at a minimum, school officials chose a natural-gas-powered system with outstanding characteristics of economy and efficiency—two Ready-Power 60-ton units driven by two International U-450 engines. The IH-powered system operates from 9:30 am to 4:30 pm, bringing class-

room temperature to the desired level within 30 minutes. Water enters the line at approximately 90° F and leaves the system at 48° F. Return water is approximately 51° F. The separately-housed system keeps 24 classrooms and the gymnasium at about 72° F regardless of outside temperatures.

When you turn to International for air-conditioning power, you join an ever-increasing number of engineers and contractors who specify IH engines for dependable, low-cost installations. The wide range of sizes in the IH line—35 diesel and carbureted models from 16.8 to 385 max. hp—gives you matched power for all heavy-duty jobs. For complete information contact International Harvester Co., Engine Sales Dept., Melrose Park, Ill. For specific information on air-conditioning, fill out the coupon on the page opposite.



INTERNATIONAL

ENGINES

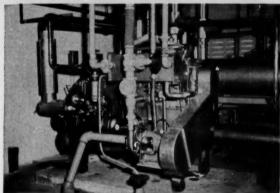
International Harvester Co., 180 North Michigan Ave., Chicago 1, Illinois A COMPLETE POWER PACKAGE

New Key to Low-Cost Municipal Air Conditioning



Mr. R. R. McKiel

ADDRESS



Officials who specified cooling equipment for the Clearwater project naturally turned to the most economical units they could find. Two natural-gas-powered International U-450 engines drive two Ready-Power water chillers in this low-cost system. Installations throughout the country indicate that International engines provide the most economical air-conditioning power available.



Operating Engineer J. E. Pratt controls temperature of each room and gymnasium from this master panel. Each classroom accommodates 35 students. The school began with 665 students, now has a total enrollment of 1,200. Provisions have been made for additional air-conditioning equipment as extra rooms are added to the present facility.

For descriptive literature spelling out the advantages of International natural gas powered air-conditioning, send for colorful, illustrated booklet.

Fill out the coupon and mail it today!

Circle 281 on Page 19

Engine Sales Dept.	
International Harvester Co.	
Melrose Park, III.	
Please send me the booklet on natural gas air-conditioning.	
NAME	
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46L (with adjustable draw hook)

— All the features of type
46L plus draw
hook adjustable
overa ½"range.



51L — Ultimate tensile strength up to 500 lbs. Hook adjusts by simple rotation over 1/16" range.

There's a Camloc Fasten/eered Universal Latch to do the job... and do it better!

You may never have to crate an anteater or ship a zebra. It's just one way of demonstrating the wide range of tensile strength requirements met by Camloc Universal Latches. For any job . . . from A to Z . . . 500 pounds or 4500 pounds . . . shipping containers or component assemblies of any size . . . Camloc can provide the latch to fill your specifications.

At Camloc the science of modern fastening is called FASTEN/ATION. And, FASTEN/EERED Camloc latches provide the ultimate in protection, ease of installation, and simplicity of operation. For example: draw hooks always stow flat when latches are open. Latches can't open under shock or vibration. Clean, crisp appearance enhances any product or component.

Have a special fastening or closure problem (even a reusable zebra case)? Camloc can provide a FASTEN/ATING solution. Write today

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AMLOC

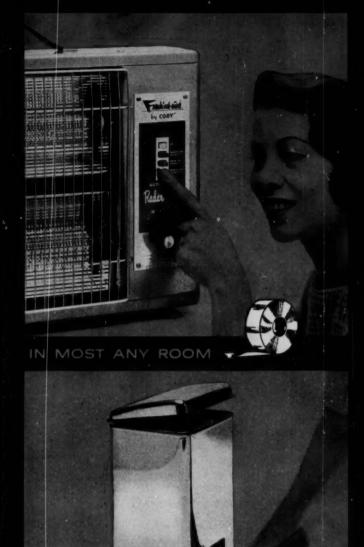
specialists in fasteners for industry

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These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).



Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 24" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.



Quality plating produces metals so durable they can be fabricated, even quite severely drawn or bent. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done. These handsome articles of daily use are striking indeed! Not a little of this is achieved by the functional use of bright plated Nickeloid Metals in Chrome, Brass or Copper finishes. But look again! These pictures carry a deeper, even more dramatic story... the story of a new concept of manufacture. Not always do artisans work with raw steel sheet. Not always is the final finish applied by the extra step of painting or plating. With Nickeloid Metals this finish is built-in, and it's done by a company which has dedicated itself to electroplating of sheets and coils for industry for over 60 years! The use of Nickeloid Metals as a pre-finished raw material proves the theorem that a straight line is the shortest distance between two points. Write for free Introductory Kit that unfolds the entire story and provides you with metal samples. Or, phone a Nickeloid sales office in one of the principal cities.

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All Pressure Regulators are not alike

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Floating Valve-Pin

A Norgren <u>extra</u> that assures leak-proof seating of the regulator valve

A tight, leak-proof seating of the valve is essential to the proper performance of a pressure regulator. Leakage and creep can be caused by improper alignment of the valve-pin, resulting in gouges and excessive wear on the valve seats.

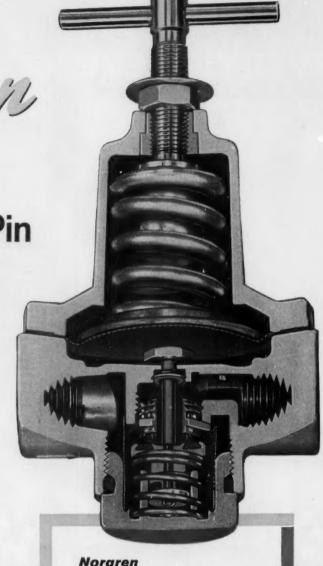
To prevent this, Norgren Regulators are made with a floating valve-pin, eliminating critical alignment problems. The Norgren floating valve-pin is self-aligning, assuring positive seating of the valve. As a result, there is minimum wear on the valve seat, with increased service life and more dependable regulator performance.

Whatever your pressure regulation need, there is a Norgren Pressure Regulator designed for the job. Call your nearby Norgren Representative listed in your telephone directory—or write factory for literature showing complete Norgren Regulator line.

FOUNDED IN 1926

C. A. NORGREN CO.

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Norgren Pressure Regulators give you these important features:

Balanced Valve Construction improved regulator performance

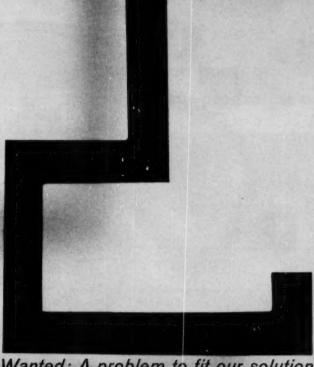
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Easy servicing while still on fluid-line

Floating Valve-Pin assures better seating



Wanted: A problem to fit our solution

Somewhere, there's an engineer with an industrial control problem. We don't know what it is, but we'd like to meet him. We don't even know what industry he works for.

We know it isn't the tobacco industry.

You see, we've been in the tobacco machinery business for over fifty years. As a matter of fact, American Machine & Foundry Company's Standard Cigarette Machine revolutionized the world's smoking habits in 1907, and AMF has kept its lead in this field ever since.

The reason? AMF research and development teams. involving over 1600 scientists working all over the world, have consistently come up with machinery to solve the tobacco industry's problems more efficiently and more profitably. Engineers in the tobacco industry know all this. But, our R&D people tell us that many of the machines we are selling to the tobacco industry have potential application to other industries.

What other industries? They can't tell us-yet. They can tell us what general areas are most likely to produce the kind of problems for which they have the solutions. A maker of a small packaged product, like soap or a pharmaceutical, where accurate weight control is the difference between profit and loss; a maker of a packed and cartoned product (playing cards? candy?) may be interested in a packing machine that can be adapted to his product. A processor of a large, loose raw material may be interested in how AMF developed tobacco leaf handling and processing systems -and want to apply the same know-how to wasteful, uneconomic hand operations. The use of electronics as a method of control of high-speed inspection, correction and packaging may interest another industry.

The engineer we're looking for is pondering his problem. We wish he'd let us ponder it with him.

AMERICAN MACHINE & FOUNDRY COMPANY (Amf EXECUTIVE OFFICES, AMF Building, 261 Madison Avenue, New York 16, New York



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DUE BOSSI BOTTON AND THE BOTTON AND THE BOTTON

an element here
and an element here

assures 99.98% filtration efficiency even when 1 element is out of operation

IT'S THE NEW PUROLATOR TWO-STAGE FILTER

Simplicity of design makes the first cost of Purolator's new dry-type two-stage filter as low as any two-stage filter on the market. Each element filters independently, and together they dustproof your engine as no other filter can...99.98% efficient.

Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Another big user-advantage is the way the two-stage design protects the engine despite accidental mishandling of the element. Even if the first stage element is damaged, the chance of harming the engine can be discounted when it is protected with the second stage back stop element. In addition, the second stage element lets the operator service the unit in the field, regardless of how dusty the conditions are.



Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic impregnated cellulose. This series of two-stage filters is rated from 450 to 1150 cfm, with exceptionally low initial restriction. Mounting straps, rainhoods and outlet adapters are available.

For more information write to Purolator Products, Inc., Department 3896, Rahway, New Jersey.

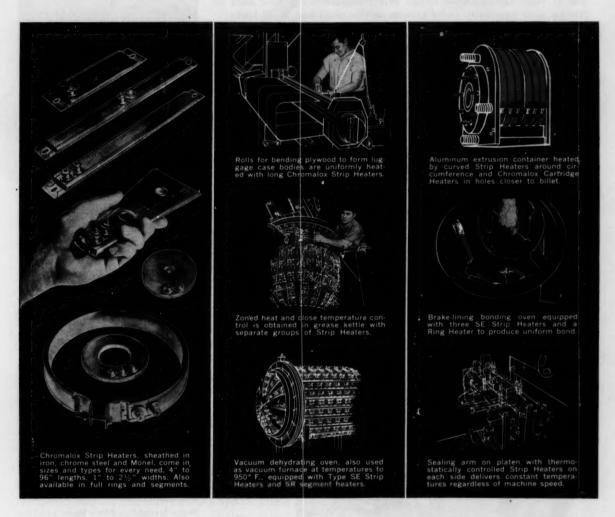
Filtration For Every Known Fluid

PURQLATOR

PRODUCTS, INC.

CHROMALOX ELECTRIC STRIP HEATERS

Versatile, dependable, uniform heat for your product or processing needs



Compact, metal-sheathed Chromalox Strip Heaters assure accurate temperatures, dependable around-the-clock service anywhere heat is needed for product or process. It is by far the most versatile built-in heat source available today. Easy to install—Chromalox Strip Heaters produce uniform and accurate temperatures with automatic or manual controls.

Low initial cost, low installation costs and low operating costs are among the many other advantages of using Chromalox Strip Heaters for heating tanks, platens, ovens, molds, moving parts, and similar uses. Over 500 standard sizes, shapes, ratings and terminal arrangements available immediately from stock. Get the full details now.

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Write for Industrial Processing Catalog 60, Comfort Heating Catalog F-975D, Infrared Catalog G-62.



EDWIN L. WIEGAND COMPANY

WI-10



CHROMALOX

PROCESS COMFORT

THEY LAST LONGER!

-America's Quality Pillow Blocks

For 37 years Dodge Pillow Blocks with Timken Bearings have been proving their superiority under extreme service conditions in *all* kinds of applications throughout industry.

They are noted for their ruggedness. They are built to outlast the demands of the jobs on which they are used. And they carry their loads—radial and thrust, or any combination of the two—with minimum attention.

Dodge takes no chances with the fine precision built into these pillow blocks. They are painstakingly assembled, expertly adjusted, pre-lubricated and SEALED at the factory. You slip them onto your shaft in mint condition—and they stay that way!

There are 5 types of Dodge Pillow Blocks with Timken Bearings—Type E, Double Interlock, Type C (all with shaft sizes from 1-7/16" to 4-15/16", and down to 1-3/16" in Type E), Special Duty with shaft sizes to 12" and All-Steel—2-15/16" to 10". Available from your Dodge Distributor's stock. Call him, or write us for technical bulletin.

Dodge Manufacturing Corporation, 3300 Union St., Mishawaka, Ind.



Dedge Type E Pillow Blocks with Timken Bearings used for the drive hook-up of a rotary percussion drill.

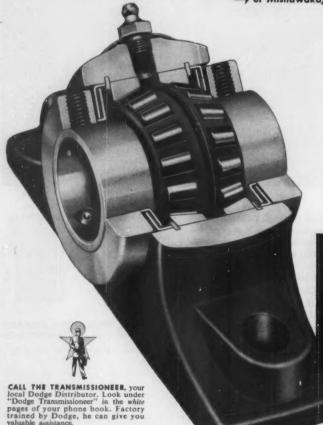


Dodge Type C Pillow Block with Timken Bearings in cement plant — one of 4 in use on clevators since 1930.



Dodge Special Duty Pillow Blocks with Timken Bearings used on a skip hoist bull wheel for a blast furnace.

The Products with the Pluses ... DODGE



DODGE PILLOW BLOCKS

TIMKEN BEARINGS



To produce jam-free staples calls for absolute uniformity of wire temper and diameter and unvarying staple dimensions. Holding to tolerances of plus or minus .0005", International Staple and Machine Company, Herrin, Illinois, manufacture their Gold Crown® carton closing staples. The wire used is a special bright finish, copper-coated steel wire of cold rolling quality furnished by Keystone Steel & Wire Company. This round steel wire must have (1) correct temper throughout the coil, (2) critical tensile range and (3) a copper coating which works perfectly with International Staple's high-speed staple forming machines.

Mass production of steel staples by International Staple has been increased because of the forming characteristics of Keystone Wire which allow the wire to conform exactly to required tolerances and shaping. In addition Keystone designed and built a platform carrier to control wire take off. This carrier means less scrap, longer runs, better protection in transit, better storage, easier wire handling and less time to set up the wire for the cold rolling operation.

Specifications for your product can be accurately analyzed and every detail closely controlled at Keystone. The wire you require can be uniformly produced through the latest and most exact methods known to the steel industry. Send us your specifications for our recommendations.

No. 16 platform carrier 600 lbs. continuous coil.



Keystone Steel & Wire Company . Peoria, Illinois, U.S.A.





KEYSTONE

MADE AT PEORIA, ILLINOIS, U.S.A.

NEW 20-AMP Variable Transformer



OHMITE SERIES VT20

FEATURES

Base has elongated mounting holes and other features which give the VT20 universal mounting capabilities. Can be used as a direct replacement for other popular transformers of comparable size.

Radiator plate is counterbalanced in conjunction with the brush assembly for smooth operation and stability under vibration.

A.B. Unusually fast heat dissipation results from carefully designed base and radiator plates.

a Adjustable shaft extends from either end of the transformer as required for panel or horizontal surface mounting. Unique, collet-type lock permits repositioning without scoring or defacing the shaft.

Extra large brush assembly gives a big margin of heat dissipation . . . is accurately counterbalanced by radiator plate design.

NOW 4









SHOWN 3/3 ACTUAL SIZE

Terminal panel allows quick arrangement of clockwise or counterclockwise increase of voltage for "line" (120 V) or "overvoltage" (140 V) maximum output.

VT20 VARIABLE TRANSFORMERS CURRENTLY STOCKED

Cat.	Input	(Sing. Ph.)	Outpu	Rot.	
No.	Volts	cps	Volts	Amps	Ang.
VT20 VT20B	120	50-400	0-120/140	20	317°

WRITE FOR BULLETIN 165

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June 8, 1961



Ideas, Things, Money, People

E NGINEERS are likely to graduate from college with the notion that Engineering, with a capital E, is a homogeneous profession. Behind the idea lies the reasonable supposition that our similarities outweigh our differences. In the broader aspects of professional life this may be true.

Nevertheless, anyone who belongs to or visits a variety of engineering societies is well aware of differences which are more than subtle.

At the working, technical level the differences are even more marked. Ralph Smith, in his book Engineering as a Career, pictures engineering as a "spectrum" with bands representing Research, Development, Design, Production, Operation and Maintenance, Application and Sales, etc.

Within each band the relative emphasis on Ideas, Things, Money, and People is indicated. The differences, obviously, are quite pronounced between functions.

In terms of the kinds of people involved, the engineer toward the R & D end of the spectrum might be almost indistinguishable from a cloistered scientist absorbed in ideas and things. His brother engineer in

application engineering might look like an extrovert salesman by comparison. Their interests and personalities may be as different as night and day, though they are both engineers.

It follows that engineering departments have different personalities, too. We have yet to hear of any engineering department winning a popularity contest. But undoubtedly a sharper appreciation of its own personality, in line with its function within the total organization, could greatly improve many a department's value to, and acceptance by, others in the company.

How to rate the engineering department's composite personality is told in George Lennox's article overleaf. It is closely tied in with the interests and personalities of people.

Individual engineers seeking the optimum in career satisfaction might well consider the alignment of their department's personality and their own bent. The ideasthings-money-people mix is a useful yardstick with which to measure your own interests. How do you fit?

bolin Carmilael

Every engineering group has a distinct "personality" created by the mix of people, jobs, and responsibilities. How does yours stack up? Is it creative? Conservative? Or half and half? To find out, try this simple plan for rating

The Engineering Department's Personality

THE engineer's personality and how it relates to his job performance has been a subject of intensive study in recent years. But little attention has been focused on the composite personality of an engineering organization in relation to the role it must fulfill. Such information provides an insight into organizational strengths and weaknesses, and can be a powerful aid in managerial planning and decision-making.

Sometimes, the lack of attention to group evaluation is understandable. Many organizations have only one basic function, and personality requirements closely parallel those of the successful individual in that organization. For example, conservatism and accuracy are required of both the accountant and the accounting department.

However, the situation in an engineering department is normally quite different. In most concerns, the engineering department is expected to fulfill at least two basic functions, each of which requires entirely different, and often incompatible, personality traits:

- Productive function. This area of responsibility covers design and development of new products. Creativity, imagination, and the open mind are of utmost importance, with youth and impatience often typical characteristics,
- Servicing function. Duties here include activities such as furnishing manufacturing drawings, specifications and parts lists; testing; and reviewing products. These duties must all be handled with a high degree of dependability, accuracy, and discretion. Maturity and experience normally complement these traits and improve the quality of performance in this area of operation.

To be an asset to the company, the engineering department must be able to perform all required functions satisfactorily. In many organizational setups, the engineering department may have additional functions such as sales engineering, or phases of industrial or manufacturing engineering. Each of these activities has its unique personality requirements.

Frequently, a department may be doing an excellent job on one phase of its duties and failing com-

GEORGE C. LENNOX

Manager of Engineering Lux Clock Mfg. Co. Inc. Waterbury, Conn.

pletely in another. Management is more likely to lose patience with this situation than if the engineering group is merely doing a passable job in both areas of operation. Today, the squeeze between the competitive pressure for new and improved designs, and the demand for better product quality does not leave much room for mediocre performance in any phase of an engineering operation. As a result, all tools available for the analysis of group capabilities become important.

Consider the situation where all engineering personnel in a department are of an extremely cautious, conservative nature and lack imagination and initiative. This department will undoubtedly do a good job of handling the service function, but it will have little to offer in the way of new products. If all personnel are independent, creative, and quick to be interested in new ideas, but lack accuracy and dependability, the servicing function of a department will suffer.

Of course, no department will be made up entirely of individuals with similar personalities. However, because of the proportions of personality mix, type of supervision, and relative job levels of individuals, the resultant composite personality is often just as crippling as the extremes.

When the divergent personality requirements for the varied functional duties of a department are recognized, there is often a temptation to use this knowledge to rationalize the success or failure of a group, or to predict its probable future operation. However, to specifically identify and measure the extent of strengths and weaknesses in a department, systematic personality analysis is required. Such a procedure is outlined on the next two pages. This rating plan, although simple, can be informative when applied objectively and with sufficient understanding of individual personality traits.

To gain the most from this study, the analysis of results should not be concluded when the final composite personality rating is determined. Scoring sheets for both individuals and functional areas should also be examined. Particular attention should be directed at the relationships between personality ratings and level of responsibility. For example, does the drafting room checker score high on the servicing function, or do the results indicate that he might actually be better suited to design work?

A vital point which may be highlighted by this study is whether or not the manager of engineering, or chief engineer, is sharing the important decision-making responsibilities with his supervisors and engineers. In any department, the manager's personality is a key factor. However, if the engineering department is being run as a one-man operation, an objective study should show a composite personality that is dominated by this one individual.

Such corollory information resulting from a thorough analysis may be significant, but one fact should always be kept in mind. The principal purpose of this study is to provide a composite personality rating for a group, not an individual. The procedure outlined here was developed for the engineering department of a medium-size company. However, the principles and concepts are applicable to engineering groups of comparable size in any company, large or small.

Personality Rating Plan

for engineering departments

The procedure presented here was developed to provide an approximate rating of the composite personality of an engineering group. To demonstrate this approach, a representative engineering department is appraised. It is made up of 30 employees, and consists of a product design group, drafting section, laboratory, model-room, and liaison-engineering group which handles field and shop problems.

1. Determine Functions to be Performed.

Analyze the department and its relationship to company operations. Study its duties and resolve its fundamental functions.

In the example department, these responsibilities are found to be:

- Servicing the manufacturing department with specifications and drawings, including authorization of deviations and changes for cost reduction.
- Production of new designs and products. Responsibilities include not only improved design to replace old products, but also new items for new markets.

2. List Individuals in Functional Areas.

Divide individuals into groups according to function, placing each person in the area where he most influences decision making. If an individual—such as the manager of engineering, supervisor of model room, or some specific engineer—contributes to both functions, he should be so listed.

Classify Individuals by Degree of Decision-Making Responsibility in Functional Area.

Analyze each functional group, and rank listed individuals by degree of responsibility. This rating, as well as the previous listing, must be on the basis of actual assumed responsibility, not by position title or plan of organization.

The forms displayed here show typical working charts for the listing and rating of individuals. The function chart has provisions for entering the results of the remainder of

/	A) Servicing the Ma	nufacturi	ng Dept		PERCENCE:	(B) Production of 1	New Designs		
PUNCETON:	n/ screen					and Produ	icts		
Considerable Decision Maxies Dept. or Section Responsibility	Mgr of Engineering Chief Draftsman Mgr Liaison Eng Lab Supervisor	SPORSIBILATY FACTOR 35 35 35 37	PERSONALITY BOOKS 6 9 9 8	#EIGHTED 8CORE 18 27 27 24	erable Decision biling r Section Ibility	Mfg of Engineering Senior Engineer	RESPONSIBILITY PACTOR 3X 3X 1X	PERSONALETY SCORE 12 6	WEEDETE SOORE 36 18
Supervised Doctrion Parking Assigned Projects	Checker (Drafting) Model Room Supervisor Design Draftsman (R.V.) Layout Draftsman (F.R.) Liaison Engineer (C.M.) Draftsman (T.T.) Lab Technician (D.R.)	2x 2	8 13 7 6 7 5	16 26 14 12 14 10 16	d Decision Rg Trajects	Design Engineer(F5) Design Engineer (G5) Design Engineer (CP) Design Engineer (CP) Stylist		10 9 11 6	20 18 22 /2
Minor Decision Making Suggestions on Assignments	Model Maker (N.L. Model Maker (R.F.) Praftsman (A.B.) Draftsman (B.C.)	1X 1X	10 8 11 5	10 8 11 5			IX IX IX IX IX IX	7 4 8	7 4 8

the analysis. For the example department, individuals are listed by title and job; however, best practice is to use proper names. The names serve as a constant reminder that specific personalities are being dealt with, rather than merely an organizational chart.

In the listings for the example, note that two modelmakers assume responsibility for proper specification of product while another modelmaker makes creative suggestions on product design.

4. Develop Personality Scores for Each Individual.

Rate each individual in a functional area for the eight qualities selected as applicable to that function. The rater should be of a discerning nature and should have unbiased knowledge of the individuals. Cross rating, with personnel rating each other, and themselves, has been used with good results.

The final personality score is computed by giving two points for each "Extreme" quality and one point for each "Moderate" quality.

The total is entered on the working chart for the individuals under applicable function.

For the example engineering department, completed individual rating charts are shown for the manager of engineering, model-room supervisor, and a design engineer.

Calculate Composite Personality Score.

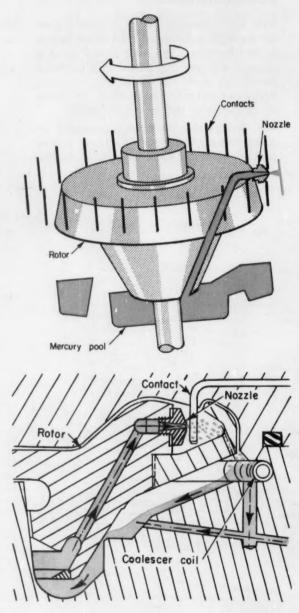
Multiply the individual personality score by the responsibility factor on the working sheet, and then total these weighted scores for each functional area.

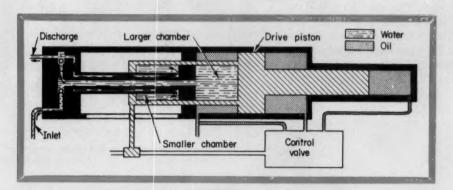
In the example, this computation gives a composite personality rating of 238/163 (servicing/productive) for the engineering department. This rating indicates that the department approaches the condition of a balanced operation. However, if new product development is to be given equal or higher priority than the servicing function, effort should be made to further develop the creative qualities of the product designers and particular emphasis should be placed on these attributes in the hiring of any additional engineering personnel.



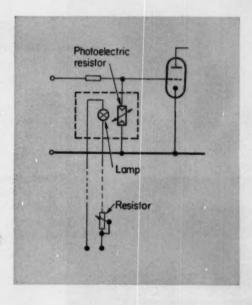
scanning the field for ideas

Mercury jet forms wiper arm in a commutating switch. The central rotor incorporates a centrifugal pump which ejects the mercury in a fine solid stream against the peripheral contacts. Principle employed in a high-speed commutating switch by Advanced Technology Laboratories, Mountain View, Calif.





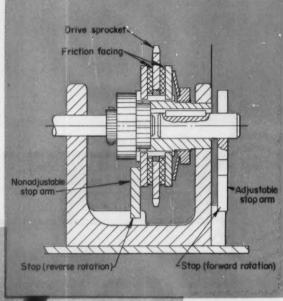
Half of output recirculates in a direct-driven pump to provide double-acting output even though the inlet is single acting. When the drive piston is extended by oil pressure, half of the water from the larger water chamber is forced out the discharge pipe. The other half of the water is recirculated to the smaller water chamber. When the drive piston retracts, the water is forced from the smaller chamber out the discharge pipe. Principle employed in pump by Tangyes Ltd., Smethwick, England.

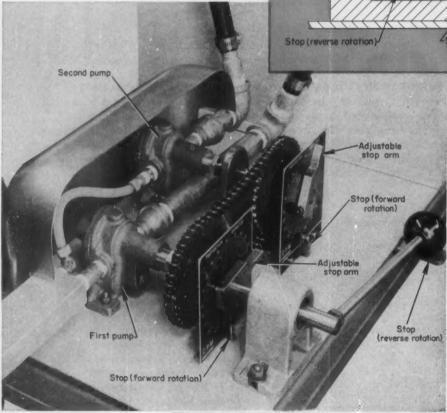


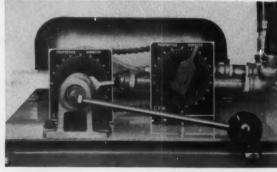
Light-controlled potentiometer provides noise-free volume control. A photoelectric resistor, exposed to a variable-resistor controlled lamp, controls the output voltage. Principle employed in a radio receiver by N.V. Philips' Gloeilampenfabrieken, Eindhoven, Holland.

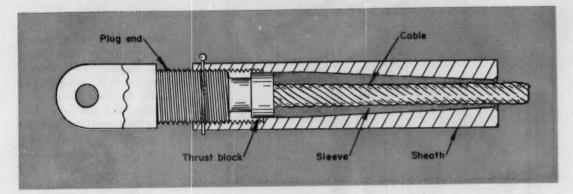
SCANNING THE FIELD FOR IDEAS

Clutch controls proportions of two materials combined by a dual-pump mixer. Rotation of the hand-operated pumps is limited to 355 deg maximum. The proportion of the two materials is controlled by the setting of the adjustable stop arms. Rotation of the handle drives both pumps until the adjustable stop arm on the second pump contacts its stationary stop. The slip clutch on the shaft of the second pump permits the first pump to continue rotation to deliver the desired quantity. Principle employed by a resinproportion mixer by CPM Special Machinery Corp., Brooklyn, N. Y.

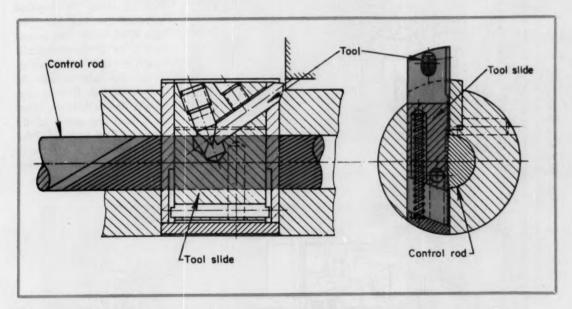




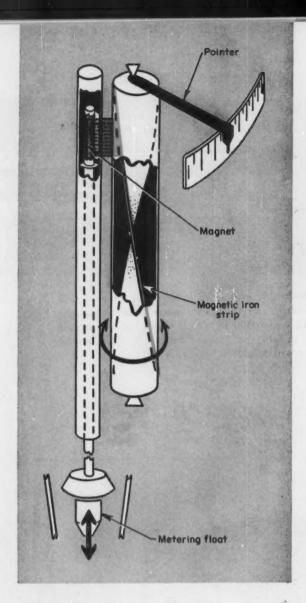




Deformable swaging sleeve permits a cable fitting to be attached to a cable with hand tools. An internally tapered sheath, when screwed onto the threaded portion of the plug end, compresses the ductile sleeve into the strands of the cable. Principle employed in cable-end fitting developed by Aviation and Engineering Projects Ltd., Hounslow, Middlesex, England.

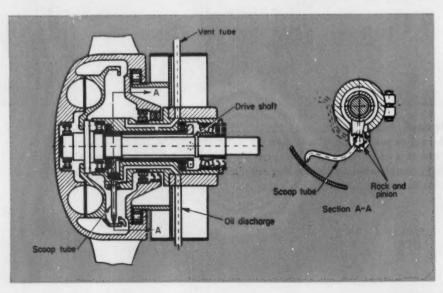


Diagonal teeth on the flat surface of a half-round rod permit axial travel of the rod to produce radial movement of a tool slide. Thus, the effective cutting diameter of a boring bar can be progressively increased while in operation. Crossfeeding principle employed in a boring mill designed by Nabenfabrik Alfing Kessler KG, Wasseralfingen, Germany.

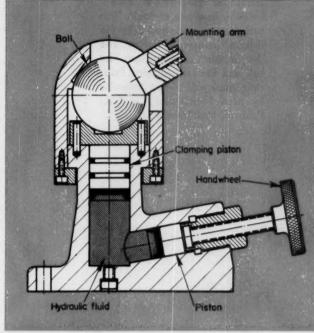


Magnetic helix converts linear input to rotary output. The magnet, which moves in response to float position, attracts the leading edge of the bearing-mounted helix. Principle employed in a flow-rate transmitter by Brooks Instrument Co. Inc., Hatfield, Pa.

Swiveling scoop tube controls amount of oil in a fluid coupling to regulate speed of a cooling fan. Position of the scoop tube is controlled by a thermostatically operated rack and pinion. When the tube is near the outside of the housing, hydraulic fluid is removed. When it is near the center of the housing, fluid is added. Principle employed in a drive by J. M. Voith GmbH, Heidenheim/Brenz, Germany.



SCANNING THE FIELD FOR IDEAS

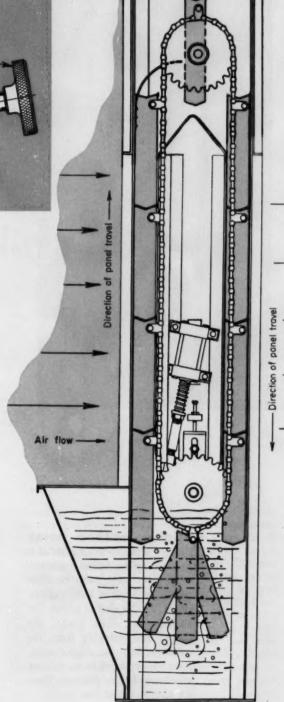


Pressure clamps ball

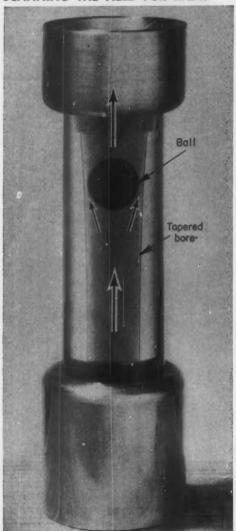
in a universal-position fixture. Hydraulic pressure, developed by the handwheel-driven piston, forces the clamping piston against the ball. Principle employed in fixture designed by Spencer Franklin Ltd., London, England.

Oil-bath "dunking"

removes contaminants to maintain efficiency of filter panels. The panels, suspended ferriswheel like on an endless chain, successively pass slowly through the cleaning bath. The filters are suspended so that they always present the same face to the air flow. Principle employed in an air filter by Air-Maze Corp., Cleveland, Ohio.

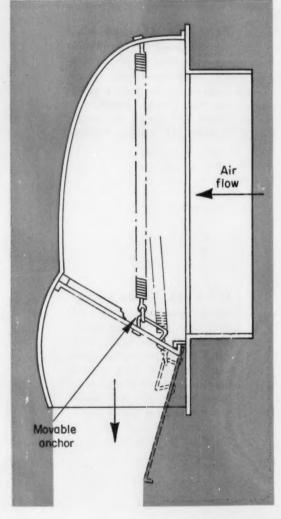


SCANNING THE FIELD FOR IDEAS



Ball in tapered tube indicates flow rate of liquid. The ball position is controlled by the balance between the flow and the annular area between the ball and the tapered bore. Principle employed in flow indicator by Alan Muntz and Co. Ltd., Feltham, Middlesex, England.

Sliding anchor point changes effective lever ratio of a restoring spring. In the upper position, the lever ratio provides maximum force to hold damper closed. As the shutter opens, the anchor point slides toward the hinge, thus reducing force required to keep the shutter open. Principle employed in an exhaust ventilating fan by Emerson Electric Co., St. Louis, Mo.



How Clearance Affects Life of Rolling Bearings

JOHN H. RUMBARGER

Design Analyst Messinger Bearings Inc. Philadelphia, Pa.

eloads aslearance->

NTERNAL clearance or preload in a ball or roller bearing can diminish bearing life to a marked degree. Most bearing applications involve bearings of small and medium sizes; they may be handled by the use of standard catalog bearings with little concern over the actual magnitudes of clearance.

Those applications, however, in which more internal clearance than normal is required or in which preload is high may well be examined for predicted life. How to calculate the probable bearing life for any amount of clearance or preload is presented in this article.

Clearance and Preload: Diametral clearance is that

amount by which the inner race is smaller in diameter than the diameter required for size-to-size metal contact of the rolling elements and the races. If the diametral clearance is negative, which means that the inner race is larger in diameter than the diameter required for size-to-size metal contact of the races and rolling elements, the bearing is "preloaded." In such a case, the rolling elements are compressed and exert a force on the races without an application of external load.

Diametral clearance (or preload) as used here is assumed to be the clearance (or preload) within the mounted, but otherwise unloaded, bearing at normal operating temperatures. The use of bearings in unusual or demanding applications involving heavy loads, high speeds, low deflection, and elevated temperatures present many varied problems; mounting fits of the bearing on the shaft and in its housing necessarily affect the diametral clearance. High temperature differentials between the inner and outer races also affect diametral clearance, sometimes greatly. Preload is often employed to limit overall deflections of a system when accuracy in positioning may be required. The selection of mounting fits, employment of preload, and temperature problems are well understood, but it is also important to be able to evaluate the relative effects of them as they contribute toward changes in the diametral clearance of the bearing and in its calculated dynamic life.

Load-Distribution Relationships: The assumption is made that the bearing races are rigid bodies with elastic properties at the contacts between the racerolling elements. Fig. 1 pictures a radial rolling-element bearing (zero^{1,2} contact angle) with no externally applied load.

Fig. 2 pictures the same bearing after the application of an applied load F_r which displaces the inner race and elastically deforms the rolling elements in the shaded load zone.

References are tabulated at end of article.

Nomenclature

- C = Basic load rating. The load that bearing could endure for one million revolutions of inner race, lb
- D = Ball or roller diameter, in.
- D_i = Diameter of inner ring contact surface, in.
- d_m = Pitch diameter of rolling elements, in.
- Fr = External radial load applied to bearing, lb
- f = Material factor, determined by experiment
- = 7450 for ball bearings when pound and inch units
- = 49,500 for roller bearings when pound and inch units are used
- $f_c =$ Factor for dynamic capacity, Tables 2 and 3
- H = Minimum life, hr
- $J_r(\varepsilon) = \text{Load}$ distribution integral dependent upon extent of load zone ε
 - K = Deflection constant
 - L = Life of bearing expressed in millions of revolutions of the inner ring, mr
 - leff = Effective length of a roller, in.
 - N = Speed of rotation, rpm
 - P_D = Diametral clearance, in.
 - Q₀ = Rolling-element load at angle from position where rolling-element load is a maximum, lb
- Qmax = Maximum rolling-element load in bearing, lb
 - V =Rotation factor
 - Z = Number of rolling elements in bearing
- δ_{max} = Deflection of maximum rolling-element load, in.
 - δ_r = Displacement and deflection of inner ring from centered position in outer ring, in.
 - e = Measure of extent of loaded zone
 - λ = Reduction factor for stress concentration
 - φ = Angular position of any rolling-element load Q_φ, deg

Maximum deflection of the loaded rolling element occurs at $\phi = 0$ deg and is

$$\delta_{\max} = \delta_{\tau} - \frac{P_D}{2} \tag{1}$$

The deflection of any rolling element in the bearing is

$$\delta_{\phi} = \delta_{\tau} \cos \phi - \frac{P_D}{2} \tag{2}$$

By substituting Equation 1 into Equation 2,

$$\delta_{\phi} = \delta_{\text{max}} \left[1 - \frac{1}{2s} \left(1 - \cos \phi \right) \right]$$
 (3)

where coefficient

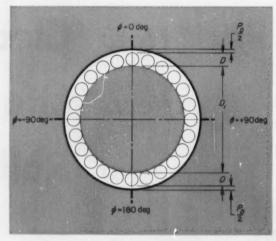


Fig. 1—Radial rolling-element bearing with no externally applied load. Inner race is centered with respect to outer race.

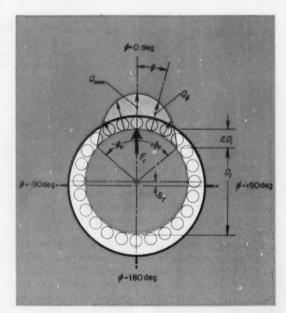


Fig. 2—Radial rolling-element bearing with external radial load F_r . Shaded area indicates distribution of load over rolling elements within loaded zone.

$$\epsilon = \frac{1}{2} \left(1 - \frac{P_D}{2 \delta_r} \right) \tag{4}$$

and depends on the extent of the loaded zone, Fig. 2. The angular extent of the loaded zone is $\pm \phi_0$. From Equation 2 for $\delta_{\phi}=0$,

$$\phi_0 = \arccos \frac{P_D}{2 \, \delta}. \tag{5}$$

The load acting upon a rolling element as a result of its elastic compression may be expressed in the form:

$$Q_{\phi} = K(\delta_{\phi})^{t} \tag{6}$$

where t = 1.5 for point contact and t = 1.11 for line contact. Thus,

$$Q_{\text{max}} = K(\delta_{\text{max}})^t = K\left(\delta_r - \frac{P_D}{2}\right)^t \tag{7}$$

For a ball bearing (point contact) with innergroove radius at 52 per cent of the ball diameter and with outer race groove radius not greater than 53 per cent of the ball diameter, K is approximated by^{2,3}

$$K \approx 14.2 \times 10^6 \, D^{\frac{1}{3}} \tag{8}$$

For a roller bearing (line contact) with crowned

Table 1-Load Distribution Integral J. (e)

8	Point Contact	Line Contact		Point Contact	Line Contact
0	0	0	0.8	0.2559	0.2658
0.1	0.1156	0.1268	0.9	0.2576	0.2628
0.2	0.1590	0.1737	1.0	0.2546	0.2523
0.3	0.1892	0.2055	1.25	0.2289	0.2078
0.4	0.2117	0.2286	1.67	0.1871	0.1589
0.5	0.2288	0.2453	2.5	0.1339	0.1975
0.6	0.2416	0.2568	5.0	0.0711	0.0544
0.7	0.2505	0.2636	- 10	0	0

or end-relieved rollers, K is approximated by

$$K \approx 5.21 \times 10^6 (l_{eff})^{8/9}$$
 (9)

Substitution of Equation 6 into Equation 3 gives

$$Q_{\phi} = Q_{\max} \left[1 - \frac{1}{2\epsilon} \left(1 - \cos \phi \right) \right]^{t}$$
 (10)

Summation of the vertical forces in Fig. 2 gives

$$F_{\tau} = \sum_{\phi=0}^{2\pi} Q_{\phi} \cos \phi \tag{11}$$

and

$$F_r = Z Q_{\text{max}} J_r(\varepsilon) \tag{12}$$

where

$$J_r(\varepsilon) = \frac{1}{2\pi} \int_{-\phi_0}^{+\phi_0} \left[1 - \frac{1}{2\varepsilon} \left(1 - \cos \phi \right)^{\varepsilon} \cos \phi \right] d\phi \qquad (13)$$

Values of the load distribution integral J_r (e) are given in Table 1 for both point contact t = 1.5 and line contact t = 1.11. From

$$F_{\tau} = ZK \left(\delta_{\tau} - \frac{P_D}{2}\right)^t J_{\tau}(\epsilon)$$
 (14)

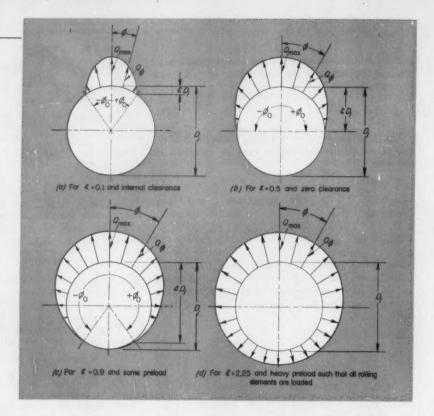
the number of rolling elements Z, and Equation 8 or 9, the deflection δ_r and the extent of the load zone ε may be obtained for any radial rolling-element bearing under radial load F_r .

Values of P_D may be assumed; then Equation 14 can be solved by the use of the tabular values of J_r (ε) and successive approximations. Fig. 3 illustrates

			ubit 2		1-00111	aci vai	ues of	racion	161 101		130			
Ratio D/dm	e = 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.25	1.67	2.5	5
0.01 0.03 0.06 0.09 0.10	0.193 0.269 0.326 0.363 0.373	0.238 0.330 0.401 0.445 0.457	0.26 0.360 0.469 0.499 0.511	0.282 0.392 0.476 0.526 0.541	0.296 0.411 0.500 0.554 0.566	0.300 0.419 0.510 0.565 0.580	0.305 0.424 0.515 0.571 0.586	0.306 0.422 0.514 0.570 0.585	0.301 0.417 0.506 0.364 0.578	0.292 0.405 0.495 0.545 0.559	0.252 0.352 0.423 0.469 0.469	0.194 0.278 0.328 0.362 0.371	0.128 0.178 0.214 0.237 0.244	0.06 0.10 0.11 0.11
0.15 0.18 0.20 0.26 0.30	0.396 0.404 0.404 0.394 0.377	0.485 0.495 0.495 0.480 0.461	0.545 0.551 0.551 0.535 0.515	0.577 0.585 0.586 0.545	0.603 0.611 0.611 0.593 0.571	0.615 0.621 0.622 0.605 0.582	0.622 0.630 0.630 0.611 0.590	0.620 0.629 0.629 0.610 0.587	0.613 0.620 0.620 0.603 0.580	0.592 0.601 0.600 0.582 0.562	9.516 9.516 9.516 9.501 6.483	0.394 0.400 0.390 0.396 0.372	0.256 0.261 0.261 0.252 0.244	0.12 0.12 0.12 0.12

		Tab	le 3-	-Line-C	ontact	Value:	s of Fe	actor f	/f for	-	49,500			
Ratio D/dm	ε = 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.25	1.67	25	5
0.01 0.03 0.06 0.09 0.10	0,050 0,076 0,088 0,095° 0,096	0.077 0.097 0.111 0.120 0.122	0.084 0.107 0.124 0.134 0.136	0.091 0.115 0.133 0.144 0.146	0.005 0.120 0.139 0.150 0.152	0.007 0.123 0.143 0.154 0.156	0.007 0.124 0.144 0.155 0.157	0.097 0.123 0.142 0.153 0.156	0.004 0.120 0.139 0.149 0.152	0.090 0.114 0.132 0.142 0.144	0.071 0.001 0.104 0.112 0.115	0.052 0.066 0.076 0.082 0.084	0.033 0.042 0.049 0.053 0.053	0.01 0.01 0.02 0.02 0.02
0.15 0.18 0.20 0.26 0.30	0.101 0.101 0.102 0.099 0.096	0.128 0.129 0.129 0.126 0.122	0.142 0.144 0.144 0.140 0.136	0.153 0.155 0.155 0.150 0.146	0.159 0.161 0.161 0.156 0.152	0.163 0.164 0.164 0.160 0.155	0.164 0.165 0.165 0.161 0.155	0.162 0.164 0.163 0.159 0.155	0.158 0.160 0.150 0.155 0.151	0.150 0.151 0.151 0.147 0.144	0 119 0 120 0 120 0 120 0 117 0 114	0.087 0.088 0.088 0.085 0.083	0.056 0.056 0.056 0.054 0.053	0.02 0.02 0.02 0.02 0.02

Fig. 3 — Load distributions for point-contact bearings with varying degrees of internal clearance and preload.



the load distributions for varying degrees of clearance and preload in terms of coefficient ε .

Basic Load Rating: The basic load rating for a radial rolling-element bearing is that constant stationary radial load which a group of apparently identical bearings with stationary outer ring can endure for a minimum life of one million revolutions of the inner ring.⁴

POINT CONTACT (BALL BEARING): Basic dynamic capacity is

$$C = f_c Z^{2/3} D^2 (15)$$

where x = 1.8 when $D \le 1.00$ in. and x = 1.4 when D > 1.00 in.

Table 2 lists values of f_e/f as a function of the ratio D/d_m and the extent of the load zone ϵ . It may be noted that for zero clearance, or $\epsilon = 0.5$, the values of f_e/f agree with those accepted as standards.^{5,6}

LINE CONTACT (ROLLER BEARING): Basic dynamic rating is

$$C = \lambda f_e(l_{eff})^{7/9} Z^{3/4} D^{29/27}$$
 (16)

Table 3 lists values of f_e/f as a function of the ratio D/d_{∞} and the extent of the load zone ϵ . For zero clearance, or $\epsilon=0.5$ and $\lambda=1.0$, the values in Table 3 agree with those accepted as standards.^{4,6}

Reduction factor λ takes into account stress concentrations in the form of edge loading and inexactly centered loads on the individual rollers, Table 4. A cylindrical roller will have line contact under no load with the mating races. The stress distribution when loaded is not uniform but increases at the

ends due to the finite length of the rollers and becomes worse with inaccurate guidance of the rollers.

"Modified line contact" pertains to departures from true cylindrical shapes, such as the crowning or tapering of rollers at the ends, and/or the crowning of raceways such that the maximum loaded roller in a radial bearing loaded with about one-half the basic load rating C will have essentially uniform stress throughout the contact area.

Table 4 gives recommended values of λ as a function of the type of contact and the degree of roller guidance.

Life: The minimum life (or *B*-10 life) of a bearing is the number of revolutions (or hours at some given constant speed) that 90 per cent of a group of apparently identical bearings will complete or exceed before the first evidence of fatigue develops.

POINT CONTACT: Life of a ball bearing in millions of revolutions (mr) of the inner race is

$$L = \left(\frac{C}{VF_*}\right)^8 \tag{17}$$

LINE CONTACT: Similarly, for a roller bearing,

$$L = \left(\frac{C}{VF_r}\right)^{10/3} \tag{18}$$

where V is a rotation factor, such that V=1.0 for the inner race rotating with respect to the load, and V=1.2 for the outer ring rotating with respect to the load.

The minimum life in hours may be expressed at

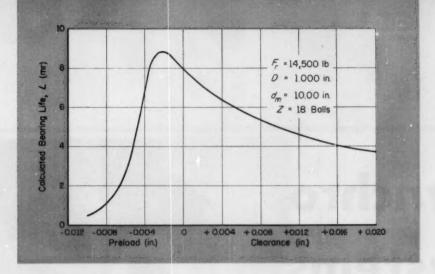


Fig. 4—Calculated life vs preload and diametral clearance for bearing of example.

Table 4—Recommended Reduction Factors λ

Relative Degree of Accuracy in Roller Guidance	Accurately guided by two integral uninterrupted guide surfaces on same race	Accurately guided by a machined cage	Not ac- curately guided	
Modified Line Contact With				
Both Races	1.0	0.83	0.73	
Line Contact With Both Races	0.73	0.73	0.65	

some constant speed by

$$H = \frac{10^6 L}{60 N} \tag{19}$$

A numerical example illustrates the computation of dynamic life of a radial ball bearing with internal diametral clearance.

Example: Given a radial ball bearing with 18 balls, 1.00-in. diameter, evenly spaced on a 10.00-in. pitch diameter. Groove radii are standard and the bearing is subjected to a radial load of $F_r = 14,500$ lb.

Determine the life in millions of revolutions for zero diametral clearance and for 0.010-in. diametral clearance.

Solution for Zero Clearance: One-half the circumference of the bearing is loaded so that $\varepsilon=0.5$ and $P_D=0$, Fig. 3b. From Equation 15 and Table 2,

$$C = 0.566(7450)(18)^{2/8}(1)^{1.8} = 29,000 \text{ lb}$$

From Equation 17,

$$L = \left(\frac{29,000}{14,500}\right)^3 = 8 \text{ mr}$$

Deflection of the inner ring is found from Equation 14 to be

$$\delta_r = \left(\frac{F_r}{J_r(\varepsilon)ZK}\right)^{1/\epsilon}$$

$$= \left(\frac{14,500}{0.2288(18)(14.2 \times 10^6)}\right)^{2/3} = 0.00394 \text{ in.}$$

Solution for 0.010-in. Clearance: Now, $P_D = +0.010$ in. Assume $\delta_r = 0.010$ -in. From Equation 4,

$$\varepsilon = \frac{1}{2} \left(1 - \frac{0.010}{2(0.010)} \right) = 0.250$$

From Table 1 for $\epsilon = 0.250$, $f_r(0.250) = 0.1741$.

From Equation 14,

$$F_{\tau} = 18(14.2 \times 10^{6}) \left(0.010 - \frac{0.010}{2} \right)^{3/2} (0.1741)$$

= 15,600 lb

which is larger than the given load $F_r = 14,500$ lb. Next, assume $\delta_r = 0.0097$ in. Now

$$\varepsilon = \frac{1}{2} \left(1 - \frac{0.010}{2(0.0097)} \right) = 0.2435$$

so that J_r (0.2435) = 0.1718. From Equation 14,

$$F_r = 18(14.2 \times 10^6) \left(0.0097 - \frac{0.010}{2}\right)^{3/2} (0.1718)$$

= 14,500 lb

which agrees with the given $F_r = 14,500$ lb.

When $D/d_m = 0.10$ and $\varepsilon = 0.2435$ are entered in Table 2, $f_e/f = 0.480$. From Equation 15,

$$C = 0.480(7450)(18)^{2/3}(1)^{1.8} = 24,600 \text{ lb}$$

From Equation 17,

$$L = \left(\frac{24,600}{14,500}\right)^8 = 4.87 \,\mathrm{mr}$$

The foregoing calculated values establish two points on the curve of Fig. 4. Others, established in the same manner, provide a curve to show how bearing life drops off with both diametral clearance and preload.

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Synchro Systems

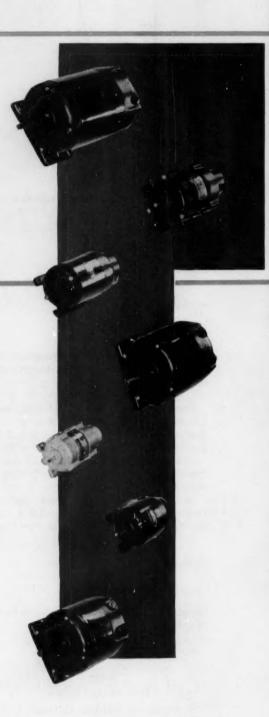
. . . for reliable transfer of positional information by the master/slave drive principle

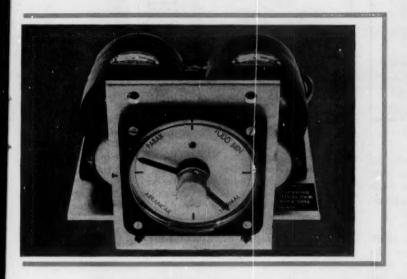
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RANSFER of data is usually essential for the automatic operation of a process or system. Synchro devices, familiar workhorses in the field of positional information transfer, provide the solution to many of the problems inherent in such automatic systems. In addition to remote indication, synchros also offer a low-cost approach to remote control.

Synchro units can be applied in almost any situation involving monitoring of mechanical or fluid motion. Receiver units equipped with instrument-type dials can provide accurate visual indications of such conditions as liquid level or weight at some remote location. Similarly, receiver units with or without indicator dials can be used at remote locations to perform useful mechanical work such as controlling an engine throttle, adjusting a potenti-





ometer, or driving a cam shaft to operate switches. Among the many useful features of synchro indicating and/or controlling systems are:

- Safety and convenience. Information can be accepted in locations too hazardous or cramped for human observation and transmitted to remote receivers.
- Economy. Standard models are low in initial cost and require little maintenance. No mechanical connection of units is required; only electrical wiring is needed.
- Flexibility. Several receiver units (at different locations if desired) can operate from the same transmitter. Also, a single receiver, in conjunction with a selector switch, can monitor several transmitter units.

▶ Operating Principle

A synchro unit is similar to a three-phase induction motor except that it has two definite field poles. The primary winding of a synchro unit is connected to a single-phase source of excitation.

Two such synchro units comprise a simple synchro system. One, the transmitter, operates as a generator at the sending station. The other, the receiver, operates as a motor at a receiving point.

Simple System: The three-phase (secondary) windings of a two-unit system are interconnected, and an ac supply voltage is impressed on the primary windings of both transmitter and receiver, Fig. 1. The receiver rotor, being free to rotate, assumes the same relative position as the transmitter rotor. As the transmitter rotor is turned, either mechanically or manually, the receiver rotor turns at the same speed and in the same direction.

This self-synchronous action occurs because the single-phase current in each primary winding induces voltages in the three legs of each secondary winding. These three voltages are unequal in magnitude and vary with rotor position. If the rotors are in correspondingly identical positions, the individual phase voltages between the two units are in balance and no current flows. If the rotors are

Fig. 1—Connection diagram for a simple synchro system.

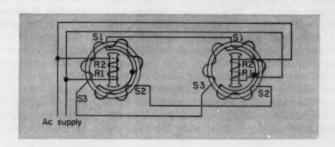


Table 1—Ratings of Typical Synchro Units

Safe Continuous Torque (oz-in.)	Statle Accuracy* (deg)	Maximum Speed† (rpm)		
2.0	5.0	200		
3.2	1.0	200		
4.0	0.3	1200		
8.0	1.0	200		
12.0	5.0	200		
50.0	5.0	1200		
108.0	5.0	1200		

"Units with greater accuracy are available with lower

torque outputs.

†200-rpm units can be supplied with 1200-rpm lubricant with some sacrifice in accuracy.

in different positions, current flows between the two units and creates a torque. This torque acts upon the rotor that is left free to turn and tends to bring it into alignment at the zero-current condition.

Differential System: A differential synchro modifies the electrical angle of a transmitter by its own angle so that an associated receiver assumes a resultant position. If desired, a differential, left free to rotate, can be connected to two transmitters. In this case, the differential assumes the sum or difference of the positions of the two transmitters.

A typical differential system contains a differential synchro interposed between the basic units, Fig. 2. The leads for both the rotor and the stator are brought out as three-phase windings, thus giving the differential synchro the form of a miniature wound-rotor induction motor. In normal operation, however, three-phase voltages and currents are not present in its windings, and the differential synchro acts similarly to a single-phase transformer.

Voltage distribution in a differential primary winding is the same as that in the secondary of the transmitter to which it is connected. If the rotor of any one of the three units in a synchro differential system is fixed and a second rotor displaced a given angle, the third rotor, free to rotate, will turn through the same angle. Direction of rotation of a differential can be reversed by interchanging any two leads on either the rotor or stator, thus providing either a sum or difference resultant.

Exciting current must be supplied to the differential primary. Since the external connections for a differential are to a receiver and a transmitter, the transmitter will logically furnish the differential exciting current. This "exciter transmitter" must have sufficient capacity to supply both its own and the differential current without overheating.

A differential synchro can be used as a receiver for direct translation of two or more rotational inputs (by means of a monitoring switch) into a rotational sum or difference. In addition, a differential can be used as a receiver/transmitter in a remote location to modify or correct positional information from another source, with the resultant

Stator winding To external field external armature Slip ring Brush holder Spring electrical connection Internal features of a typical synchro transmitter. Single-phase primary is wound on the stator (two

salient poles); three-phase secondary is wound on the rotor with connections through slip rings. Other models which have the primary located on the rotor require only two slip rings.

appearing on a designated synchro-receiver unit. Thus, differential synchros constitute the ideal automatic computer because they produce instantaneous results without encoding and decoding steps.

Accuracy

General-purpose units for data transfer are available with static accuracy ratings of 1 or 5 deg, Table 1. These ratings refer to the maximum angle of deviation between transmitter and receiver when the units are at rest and no mechanical load (other than bearing friction) is imposed on the receiver. Although manufacturers supply ratings for both static accuracy and safe continuous torque, these conditions should not be interpreted as occurring simultaneously.

Small, special-purpose units with static accuracy expressed in minutes or even seconds are available, but the torque developed per degree of displacement (torque gradient) is correspondingly low. A synchro-driven indicator with a dial 10 in. or more in diameter and with no internal gearing may be considered as having no load for most practical purposes. However, the relatively large and possibly unbalanced pointer could provide less reading accuracy when driven by a unit with a 1-min rating than if driven by a unit of less accurate 1-deg rating but of higher torque gradient.

In general, static accuracy should not be specified to a greater degree than can be read accurately on the specified scale marking. Because of the wide variety of quantities and positions that can be indicated, standard markings are almost nonexistent, but efficient processes for providing custom markings have been developed. Where calibration must be done at the application site, indicators can be

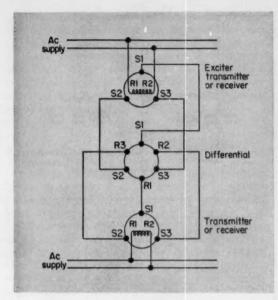


Fig. 2—Schematic diagram of a synchro differential system.

furnished with dials that have blank faces.

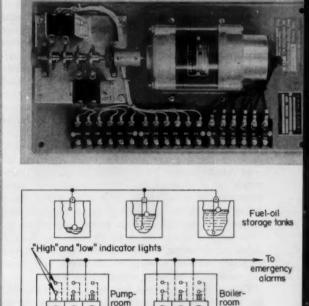
Accuracy can be improved by installing step-up gears between the prime mover and the synchro transmitter. If a 1-deg transmitter synchro were assembled with a 6:1 gear increaser, accuracies up to 1/6 deg (exclusive of gear irregularities and backlash) could be obtained. Here, of course, prime-mover speed would have to be limited to 1/6 of the maximum rated synchro speed. If a corresponding stepdown is required at the receiver, the ultimate accuracy would be reduced by the friction of the gears introduced at this point. (Since gear-friction torque of the transmitter is supplied directly by the prime mover, it is not a factor.)

▶ Speed

Synchro indicators have a speed limitation of about 1800 rpm. At some point above this speed they may snap into synchronous speed and attempt to run as motors. Also, because the normal torque gradient deteriorates at high speed, the displacement angle for a given load increases. For these reasons, top speed ratings are usually held to 1200 rpm.

In practice, rotational speed requirements for data transmission are usually much lower than 1800 rpm. Standard frame sizes of synchros are commonly rated at either 200 rpm or 1200 rpm, Table 1. The only difference between the two is in the bearing lubricant. The 200-rpm units are supplied with instrument-type oil of extremely low viscosity for minimum bearing friction. Grease-pack bearings are used on the 1200-rpm units. Both contain the same precision electrical construction, but accuracies for 200-rpm units might be of the order of 1 deg versus 2 or 3 deg for 1200 rpm units.

Synchros can also be used where periods of continuous rotation are required. For example, a transmitter driven by a fluid-metering pump can be



0

To pump-starter control

panel

Synchro

Fuel-level indication and automatic control system for a fuel-oil powered electric plant. A float-operated synchro transmitter at each storage tank controls indicators at two different locations. The synchro motors used with the indicators also drive cam-operated limit switches similar to the arrangement in the photo (indicating dial not shown). The switches control the "high" and "low" level indicator lights, the alarms when fuel level exceeds the "high" level, and a multiple-position contactor for automatic operation of pump starters and auxiliary devices. Distance between storage tanks and panel locations is approximately 1500 yd.

00

connected to a receiver which operates a revolution counter. While there are certain limitations on speed, with variations between models, such use of synchros is a matter of capability rating only. (Synchros should not be confused with tachometer generators which provide a voltage output proportional to speed.)

Torque

All synchro units depend on a relative angular displacement between interconnected rotors to produce circulating currents. These currents produce the torque which moves the connected mechanical load. The greater the load, the greater the torque

or relative angular displacement required to move it.

The expected output of synchros having the same frame size and used as pairs in a transmitter/receiver combination are shown in the performance curves of Fig. 3. As these curves indicate, synchros can develop much higher torque on an intermittent basis. This ability is an advantage when synchros are used to operate devices with high break-away friction during starting. The displacement angle cannot exceed 180 deg, but for practical purposes, it should not be greater than the peak torque angle.

If receiver units connected in a system are moved close to 180 deg out of phase while power is off—as might happen by switching to another transmitter in a monitoring system, because of panel vibration, or as a result of gravity acting on a heavy unbalanced pointer—a large synchronizing torque may be applied when power is switched on. This torque, which could be as much as 7 or 8 times rated torque, could damage the indicator or auxiliary receiver mechanism. It might also cause the receiver to motor at synchronous speed.

Consequently, synchros for use as receivers should be specified with dampers which connect inertia to the shaft through a slip-clutch mechanism. The damper limits the tendency to motoring and also

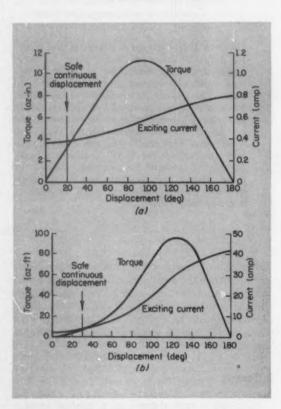
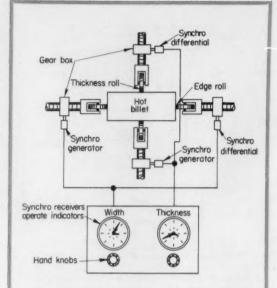


Fig. 3—Relationship of torque output and exciting current to angular displacement for typical synchro units. Curves in a are representative of models in one frame size; curves in b are representative of models in a different frame size.



Width and thickness inspection and control of steel billets. Hand knobs on panels operate differential transmitters to control zero adjust and compensate for roll wear. Synchro receivers operate the indicators. In many cases synchro transmitters can be applied directly to the forming rolls to indicate variations in the center-pass line and roll opening.

inhibits overshoot and resulting oscillation. Units in the transmitter position are usually held captive by the prime mover and a damper is seldom required. Receivers and transmitters differ only in this feature.

If more than one receiver is connected to a transmitter, and if all units have the same frame size, torque available at each receiver, T_r , can be calculated from

$$T_r = T_t \left(\frac{2}{N+1} \right)$$

where T_t is the transmitter torque, and N is the number of receivers. As the rated torque output increases, larger frame sizes are required to dissipate the heat caused by increased current.

In general, accuracy and torque are the prime factors which influence price. Speed is normally a secondary factor except for its possible influence on accuracy for a given model. For most indicating applications without gears, 2 to 3 oz-in. is sufficient torque to provide a highly responsive system with no danger of overheating. Where indicators or other receiver mechanisms include gears, torque requirements should be checked.

Power Supply

Standard units are designed to operate from a single-phase of a 115-v, 60-cps supply with volt-

age variations up to ±5 per cent. Units of similar size and characteristics can be wound for special voltages at frequencies of 25, 50, or 60 cps.

Where the local power supply is maintained above nominal or where units are located in a confined ambient, as in an explosion proof enclosure, it is wise to specify a higher-voltage winding to avoid overheating.

Transmitting Distance

Synchros are seldom used to transmit information further than several hundred feet. However, greater distances can be accommodated by compensating for the errors introduced by the connecting lines.

Resistance in interconnecting lines causes attenuation of torque and, depending on the size of the units involved, should be held to values ranging from 0.2 to 10 ohms per line. Torque/resistance characteristics for particular models should be available from the manufacturer. Excessive wire sizes often can be eliminated by using 230-v units.

Synchro primaries in a given system must always be excited from the same phase of a common power source. If necessary, line drop to a remote excitation point can be compensated for by use of an autotransformer.

Synchro differentials normally operate under poor power-factor conditions. Therefore, when more than one differential is operated in a system, regardless of distance, effective current reduction can be realized by using synchronous capacitors to improve power factor.

Applications

The versatility of synchro units and system arrangements for transfer of positional information is almost unlimited. While the basic concepts are not new, novel and different applications continue to appear. Some typical systems are mentioned here.

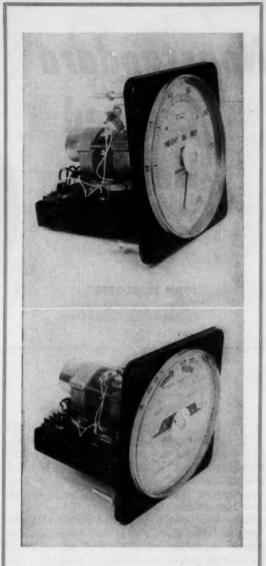
At a petroleum distribution facility, flow meters at each filler station are used to drive synchro transmitters. Receivers located in a remote control building operate revolution counters to indicate the number of gallons loaded into each tank truck.

Tension in a length of prestretched cable is measured by using synchros to monitor the movement of several points on the stretching mechanism. The synchros automatically summarize total distortion on an indicator calibrated to give a direct reading of tension.

Synchros are incorporated in many types of machine tools to supply continuous readings of positional cycle status, such as ram position in a press. They are also used for remote adjustment and visual monitoring of automated processes.

Remote indication of weight can be provided by a synchro system. Where this weight needs to be correlated with quantity or depth, as in oil-well drilling, direct translation is obtained by suitable calibration of the indicator dial.

Other typical applications of synchro units in-



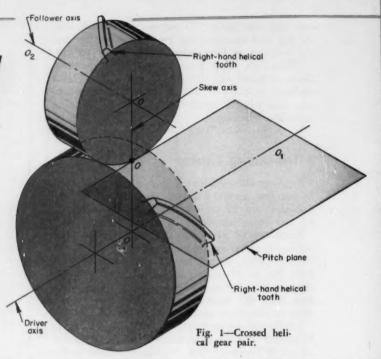
Height and skew indicators for lift bridge. Synchro transmitters in each tower lift, working into separate receivers, indicate height of the respective sides. A second transmitter in each tower, working into a differential synchro, gives visual indication of skew between the two ends and operates limit switches to initiate corrective action when the skew becomes too great.

clude: Depth of lance indication in oxygen-converter furnaces, boom and load height indication for cranes, control of turbine governors and transformer taps in power generation and distribution systems, remote potentiometer adjustment for motor control, direct and differential data insertion with visual indication for computers, gate and water-level indication and control for shipping locks and power dams.

Nonstandard Crossed Helical Gears

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H ELICAL gears offer the widest practical latitude in shaft arrangements of any type of gears. Two nonintersecting shafts, regardless of angularity, can be connected by a pair of helical gears if the shafts are far enough apart to admit gears between them and not too far apart to make gears between them impractical.¹

Gears that operate on parallel shafts² are called "parallel helical gears"; those that operate on non-parallel shafts are called "crossed helical gears." An external pair of parallel helical gears must have equal helix angles of opposite hands. An internal helical gear and its mating pinion have equal helix angles of the same hand.

Greater freedom is available in the design of the crossed helical pair. The helix angles of the teeth on mating gears can be equal or unequal and the hands can be the same or opposite.² Fig. 1 is illustrative of a crossed helical pair for which both gears have right-hand helical teeth. A right-hand helical gear is one in which the teeth twist clockwise as they recede from an observer looking along the axis.

Theoretically, the teeth on parallel helical gears engage in line contact whereas those on crossed helical gears have point contact. For this reason, parallel helical gears can transmit heavy loads while crossed helical gears are restricted to light and moderate loads. Either type transmits motion uniformly and is insensitive to changes in center distance. Crossed helical gears are also insensitive to changes in shaft angle.

Ready adjustment to such changes is one advantage of crossed helical gears over most other types of gears for running on nonparallel, nonintersecting shafts. Another advantage is that helical gears generally are manufactured on standard machine tools without special equipment. Moreover, this is true whether or not the tooth proportions are standard and the gear combinations conform to recommended practices.

These inherent properties of helical gears coupled with nonstandard proportions and conditions of operation provide unusual flexibility and economy in helical gear design. Here, the design of a 9:18 crossed helical pair of standard proportions is a preliminary problem. The main problem is to present the design procedure whereby the blank proportions established by this 9:18 gear set can be used for 32 other gear sets with ratios larger and smaller than 2. A specific series is used in explaining the design procedure but the method is general.

Gear Set Classes: The 9:18 gear pair is midway of the others, Table 1. This standard gear set is called the basic gear set and its mode of operation³ is defined as class 1, Table 2. Each of the other four classes has one or more modes of operation that is nonstandard.

Only classes 1, 2, and 3 are useful in design. Classes 4 and 5 represent unintentional operating conditions resulting from design class deviations. They are not discussed here.

Blank Dimensions for Series: Interchangeable

References are tabulated at end of article

Interchangeability, unique in the design of crossed helical gears, is achieved by 32 nonstandard gear sets based on a standard 9:18 gear set.

All 33 sets operate at 120-deg shaft angle and 1.345-in, center distance. Any one of seven drivers of 1.977-in. OD meshes in true involute action with any one of five followers of 0.839-in. OD. Numbers of teeth on drivers are from 6 to 12; those on followers from 16 to 20.

The design method is basic and can be applied to other gear combinations.

	Table	1-N	umb	ers o	f Tee	th	
			1	basic se	t		
Drivers	6	7	8		10	11	12
Followers		16	17	18	19	20	

gear sets to drive automobile speedometers are design problems where several gear ratios at one fixed center distance and shaft angle are needed to accommodate different axle ratios and tires with different rolling radii. Since speedometer drives transmit negligible power, uniform motion transfer is the major requirement. Fine-pitch gears, such as 30 diametral pitch, are usual.

Corresponding blank OD of the standard 9-tooth driver is 1.977 in. which becomes the blank diameter of the other six drivers. The blank OD of the 18-tooth driven gear is 0.839 in. and fixes the blank diameter of the other four followers. Accordingly, the blank sizes are such that each driver can mate with five followers. Thus, a total of 35 gear sets is possible from only two blank sizes. Three of the sets have 2 to 1 ratio so that the number of different ratios reduces to 33.

Fig. 2 illustrates the pronounced difference in the tooth profiles of the five followers. The series of drivers, in contrast, exhibit little difference in

Table 2—Crossed Helical Gears Classified by Mode of Operation

		er Distance————————————————————————————————————		t Angle————————————————————————————————————	Line of Action Pitch Point
1	Standard	$2C=D_1+D_2$	Standard	$\Sigma = \psi_1 + \psi_2$	Line of action intersects skew axis at common pitch point.
2	Nonstandard	$ 2C \neq D_1 + D_2 \\ = D_1' + D_2' $	Nonstandard	$\Sigma \neq \psi_1 + \psi_2 \\ = \psi_1' + \psi_2'$	Line of action passes through pitch point on skew axis. Equation 8 for ψ' , and ψ_M from subsequent calculations.
3	Nonstandard	$2C \neq D_1 + D_2$	Standard	$\Sigma = \psi_1 + \psi_2$	Line of action does not intersect skew axis. No common operating pitch point.
4	Standard	$2C=D_1+D_2$	Nonstandard	$\Sigma \neq \psi_1 + \psi_2$	Line of action does not intersect skew axis. No common operating pitch point.
5	Nonstandard	$2C \neq D_1 + D_2$	Nonstandard	$\Sigma \neq \psi_1 + \psi_2$	Line of action does not intersect skew axis. No common operating pitch point. Neither ψ_1 nor ψ_2 equals ψ_M , Equation 8.

Nomenclature

a = Addendum, in.

B = Backlash, in.

C = Center distance, in.

D = Diameter, denotes pitch diameter when used without subscript and with subscript 1 or 2 only, in.

E = Offset from skew axis of plane normal to pitch helix and containing line of action, in.

I = Interference point

L = Limit point

1 = Lead, or axial advance of pitch helix per revolution, in.

m = Contact ratio for crossed helical gears

N = Number of teeth, with subscripts 1 and 2 to denote driver and follower, respectively

P = Diametral pitch; subscript n denotes normal diametral pitch

p =Circular pitch; subscript n denotes normal circular pitch, in.

p' = Operating circular pitch, in.

R = Radius, in.

t = Tooth thickness measured on nominal pitch cylinder; subscript n and no denote normal tooth thickness on pitch and outside diameters, in.

W = Normal force on follower tooth, lb

x = Distance measured along a gear axis, in.

y = Distance measured perpendicular to gear axis, in.

p = Radius of curvature, in.

Σ = Shaft angle, deg

 ϕ = Pressure angle, deg

 ψ = Helix angle, denotes pitch helix angle when used without subscript and with subscript 1 or 2 only, deg

ψ' = Nonstandard helix angle or operating helix angle, deg

Subscripts:

B = Basic gear set

b = Base circle

d = Driving component

M = Mating gear

Teeth on

n = Normal, as p_n for normal circular pitch

o = Outside, as Do for outside diameter

s = Standard, as as for standard addendum

t= Transverse, as ϕ_t for transverse pressure angle

tooth profiles because of large helix angles.

Basic Relationships: Equations 1 to 6 are applicable to crossed helical gears of standard proportions, the basic or class 1 gear set in this article. The equations are listed without comment because they are readily verified from textbooks, ^{1, 4} handbooks, ^{5, 6} and other publications.⁷

$$D = \frac{N \sec \psi}{P_{-}} \tag{1}$$

$$a_* = \frac{1.000}{P_-} \tag{2}$$

$$C_{\bullet} = \frac{D_1 + D_2}{2} \tag{3}$$

$$rac{N_2}{N_1}= ext{gear ratio} \ =rac{D_2\cos\psi_2}{D_1\cos\psi_1}$$

Table 3—Gear Mesh Values

Driver				Follower To		16.53
Teeth		10	17	18	10	20
6	Gear Ratio	2.667	2.833	3.000	3.167	3.333
	A C	0.3626	0.3412		0.2983	0.2769
	B	0.1229	0.1156		0.1011	0.0938
	m	1.050	1.233	1.374	1.460	1.464
7	Gear Ratio	2.286	2.429	2.571	2.714	2.857
	A C	0.2561	0.2347		0.1918	0.170
	E	0.0868	0.0795		0.0650	0.0577
	m	1.164	1.346	1.487	1.574	1.577
8	Gear Ratio		2.125	2.250	2.375	2.500
	A C		0.1281	0.1067	0.0852	0.063
	E		0.0434		0.0289	0.021
	101		1.422	1.563	1.649	1.653
9	Gear Ratio	1.778	1.889	2.000	2.111	2.222
	A C	0.0430	0.0216	0.000	-0.2132	-0.0428
	E	0.0146	0.0073		-0.0072	-0.0148
	77%	1.274	1.457	1.601	1.684	1.688
10	Gear Ratio	1.600	1.700	1.800	1.900	
	A C	-0.0635	-0.0850		-0.1279	
	E	-0.0215	-0.0288		-0.0433	
	77%	1.263	1.446	1.587	1.674	
11	Gear Ratio	1.455	1.545	1.636	1.727	1.818
	A C	-0.1701	-0.1915		-0.2344	-0.255
	E	-0.0576	-0.0649		-0.0794	-0.086
	97%	1.208	1.391	1.531	1.618	1.621
12	Gear Ratio	1.333	1.417	1.500	1.583	1.667
	A C	-0.2766	-0.2980		-0.3409	-0.3624
	E	-0.0937	-0.1010		-0.1156	-0.122
	17%	1.106	1.289	1,430	1.516	1.520

Table 4—Individual Gear Dimensions

Dimension by Symbol (in.)

Driver	D	D_b	1		t _n	t _{no}	Po	P		Δρ	y _{L1}	VII
6	1.2785	0.4517	0.6361		3141	0.0177	0.9624	0.5980		3644	0.1287	0.2113
7	1.4916	0.5270	0.7421		2259	0.0214	0.9527	0.6977		2550	0.0901	0.2465
8	1.7046	0.6022	0.8482		1376	0.0237	0.9415	0.7974		1441	0.0509	0.2817
9	1.9177	0.6775	0.9542		0494	0.0248	0.9286	0.8970		0316	0.0112	0.3169
10 11 12	2.1308	0.7528	1.0602		0389	0.0244	0.9140	0.9967		0827	-0.0292	0.3521
11	2.3439	0.8281	1.1662		1272	0.0225	0.8976	1.0964		1988	-0.0702	0.3873
13	2.5570	0.9034	1.2723	0 -0.	2154	0.0195	0.8793	1.1960	-0.	3167	-0.1119	0.422
Teeth on	1	- 4		7 73	Dim	nension by	Symbol	(in.)	73,770		201900	19.00
Follower	D	D_b	1	t _n	tno	Po	p	Δρ	y _{L2}	y12	R_u	R_{τ}
16	0.6862	0.6056	2.66242	0.0879	0.008	0.2903	0.1614	0.1289	0.1138	0.1424		
17	0.7291	0.6435	2,82882	0.0701	0.017	0.2692	0.1715	0.0977	0.0862	0.1513		
17	0.7720	0.6813	2.99522	0.0524	0.022	0.2448	0.1816	0.0632	0.0558	0.1602	2	
19	0.8149	0.7192	3.16162	0.0346	0.025	0.2161	0.1917	0.0244	0.0215	0.1691		
20	0.8578	0.7570	3.32802	0.0168	0.024	0.1809	0.2018 -	-0.0209 -	-0.0184	0.1780	0.3287	0.3442

$$\Sigma_s = \psi_1 + \psi_2$$
$$l = \pi D \cot \psi$$

(5) (6)

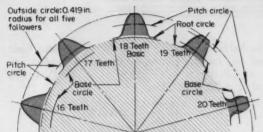
To Find Shaft and Helix Angles: Graphical and trial-and-error methods are commonly used to solve the foregoing equations. Such methods are explained elsewhere1,4,6,7 for conditions in which the defining specifications involve ratio, center distance, and shaft angle. Here, they are applied to illustrate how shaft angle and hands of helices can be determined when numbers of teeth, diametral pitch, directions of shaft rotations, and a worm-type driver make up the specifications.

Fig. 3 represents the pitch plane of a crossed helical pair like Fig. 1. The common normal to the two gear axes, or skew axis, is perpendicular to the pitch plane. Its point of piercing the pitch plane is indicated by O, Fig. 3. Line OO1 is the projection onto the pitch plane of the driver axis from beneath; OO2 is the projection of the follower axis onto the pitch plane from above. Arrows indicate the required directions of rotations of the input and output ends of the respective axes.

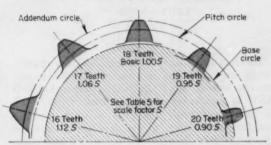
Shaft angle \(\Sigma\) is the angle between the axes, but is it 60 or 120 deg? Shaft angle depends upon helix angles, Equation 5. To find the helix angles, assume a hand of helix for driver 1, for example, LH. Since the specifications call for a large helix angle on the driver, a line is drawn through O sloping to the left and making a large angle, as 80 deg, with it. This line represents the tangent to the pitch helix on the driver, Fig. 4. It is a common tangent because the line must also be tangent to the pitch helix of the follower if proper tooth mesh between driver and follower is to be maintained.

Rotation of the driving axis exerts a force in a plane normal to the pitch helix on the driven tooth. For the direction of rotation shown, the driving component of this force may be represented by W4, perpendicular to the driven axis, Fig. 4. The driving component acts at a radius R2 below the driven axis, imparting counterclockwise rotation to that axis as viewed from the output end. This direction is opposite to that required by Fig. 3; hence, instead of a LH helix, a RH helix is needed for the driver.

It may be instructive to complete the determination of the hand of the driven helix and the magnitude of the shaft angle for Fig. 4 as drawn. The



(a) Teeth as enlarged or diminished by scale factor \$ to have equal blank dimensions.



(b) Teeth as developed by a template for 18-tooth basic follower.

Fig. 2-Transverse sections of teeth on five follower gears.

common tangent line appears to slope to the left from axis O2. But since the driven gear tooth in the mesh is below the axis, this apparent slope is just opposite to the hand of the helix, because the hand of the helix must be determined by viewing the tops of the teeth. To do this, imagine a rotation of axis O2 through 180 deg. This causes the tangent line to "flop over," veering to the right from the axis and indicating a RH helix for the follower. The helices are of opposite hand; $\Sigma =$ $\psi_1 + \psi_2 = 60$ deg, ψ_2 being regarded as a negative angle relative to ψ_1 .

Next, draw the diagram for a RH driving helix, Fig. 5. The vector W now is directed back in a general direction toward the observer as he looks along the axis O1 from the input end. The driving component W₄, acting at a lever arm R₂ below the driven axis, causes clockwise rotation of this axis as viewed from the output end. This is the direction desired, as shown in Fig. 3. The common tangent appears to veer left from the driven axis; so, actually a RH helix on the follower is indicated.

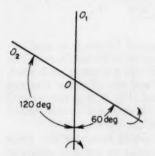


Fig. 3—Crossed axes of helical pair projected onto pitch plane with desired directions of shaft rotations.

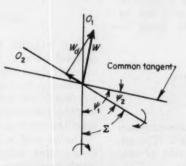


Fig. 4—Follower shaft rotation if helix on driver is left-hand.

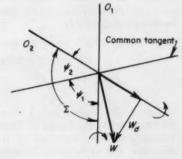


Fig. 5-Shaft rotations when both helices are right-hand.

The helices are of like hand. For the present basic gear set, suitable choices of angles and pitches are $\Sigma = 120 \text{ deg} = \psi_1 + \psi_2 = 81 + 39$, $P_n = 30$, and $\phi_n = 22.5 \text{ deg}$. Thus,

$$D_{1B} = \frac{9(6.39245)}{30} = 1.9177$$

$$D_{2B} = \frac{18(1.28676)}{30} = 0.7721$$

$$C = \frac{1.9177 + 0.7721}{2} = 1.345$$

Backlash and Blank Diameters: Backlash requirements can be handled in a variety of ways. A convenient way is this: The basic follower blank is made to standard size but the basic driver blank is made sufficiently undersize so that when a standard hob is fed to standard depth into the blank the teeth are thinned below one-half circular pitch by the amount of backlash desired. Then all driver blanks are made identical to the basic driver blank, and all follower blanks are made identical to the basic follower blank.

A standard hob is fed to standard depth into all the blanks. Tooth thickness requirements to maintain the backlash established for the basic gear set will be maintained automatically in all combinations. This method of getting tooth thickness corresponds to class 3. Equations are

$$\Delta t_{n1} + \Delta t_{n2} = 2\Delta C \tan \phi_n = 2(C - C_s) \tan \phi_n =$$

$$[(D_{1B} + D_{2B}) - (D_1 + D_2)] \tan \phi_n =$$

$$[(D_{1B} - D_1) + (D_{2B} - D_2)] \tan \phi_n =$$

$$(2\Delta a_1 + 2\Delta a_2) \tan \phi_n \qquad (7$$

Standard clearance is maintained, and only one standard hob and two blank sizes are required for the whole series. All drivers are cut with the same helix angle setting of the hob, and likewise for all the followers. One standard RH, 30-pitch, finishing hob of 22.5 deg pressure angle is required: The hobbing depth is $(2.200/P_n) + 0.002 = 0.075$ in. from nominal OD on all blanks. Complete interchangeability is assured.

With these provisions for backlash, the blank diameter of all followers is 0.772 + 2a = 0.839 in. If 0.003 in. is allowed between all gear sets for operation at 1.345-in. center distance, blank diameters of all drivers is

$$D_{o1} = D_{1B} + 2a_s - B_n \cot \phi_n$$

= 1.918 + 0.067 - 0.003 (2.414)
= 1.977

Class 2: Of classes 2 and 3, class 3 accommodates the tooth thickness change of Equation 7. This advantage has been described. It is worthy of consideration and exploitation by designers.

Class 2 obeys a different law for tooth thickness change, one closely analogous to that for parallel axes gearing. For parallel helical gears,

$$\Delta t_{n1} + \Delta t_{n2} = 2C_{\bullet}(\operatorname{inv}\phi_{t}' - \operatorname{inv}\phi_{t})\cos\psi$$

$$= \frac{(N_{1} + N_{2})\Delta\operatorname{inv}\phi_{t}}{P_{n}}$$

For class 2 crossed helical gears, the formula is

$$\Delta t_{n1} + \Delta t_{n2} = \frac{N_1 \Delta \operatorname{inv} \phi_{t1} + N_2 \Delta \operatorname{inv} \phi_{t2}}{P_n}$$

The difference of involute functions has the same value for both gears in the case of parallel axes, but a different value for each gear in the case of crossed axes, since for the latter case the two transverse planes are not coincident. Each combination is individually tailored for the desired backlash at its particular operating pitch point. Consequently, with a series of several drivers and followers, complete interchangeability is not possible. Furthermore, standard clearance is not maintained automatically. It is somewhat reduced in each nonbasic combination, unless the blanks are properly dimensioned so as to maintain it.

Although class 2 is not used here, the method for determining helix angles for operation at a common pitch point at nonstandard center distance can be described briefly. With center distance, shaft angle, numbers of teeth, and lead of one gear (either driver or follower) given, the operating helix angle of the gear whose lead is known can be found from

$$\tan^2 \psi' - \left(\frac{2\pi C}{l} - \cot \Sigma - \frac{N_M \csc \Sigma}{N}\right) \tan \psi' - \frac{2\pi C \cot \Sigma}{l} = 0$$
 (8)

Equation 8 is quadratic in $\tan \psi'$. If the values of C, l, N, N_M , and Σ are such as to yield a usable root, the value of $\tan \psi'$ closest to $\tan \psi$ is the required root. With ψ' determined, $\psi'_M = \Sigma - \psi'$,

$$p_{n'} = \frac{l \sin \psi'}{N} \qquad \qquad l_{\mathit{M}} = \frac{N_{\mathit{M}} \, p_{n'}}{\sin \psi_{\mathit{M}'}}$$

and

$$\sin \psi_{M} = \frac{\pi N_{M}}{P_{n} l_{M}}$$

If the shaft angle is 90 deg, Equation 8 reduces to

$$\tan \psi' = \frac{2\pi C}{l} - \frac{N_M}{N}$$

Class 3 Action Diagram: Inasmuch as gear sets designed for class 3 operation do not have a line of action that passes through a common pitch point, construction in design and use of action diagrams for class 3 are described. Fig. 6 is a conventional line-of-action diagram for spur and parallel helical gears and serves as a background diagram.

The lines of action extend from one base circle to the other, being tangent to the base circles at interference points I_1 and I_2 . The outside circles of radii R_{o1} and R_{o2} cut the line of action at limit points L_1 and L_2 . Contact along the line of action

(and coincident path of contact) extends from L_2 to L_1 along the solid line I_1I_2 for the direction of rotation shown. When direction of rotation is reversed, the line of action shifts to the dotted line I_1I_2 , and of course the limit points shift to this line also.

Since this diagram is for any transverse section, it should be realized that in three dimensions there are tangent planes to the base cylinders, forming ribbons of action between the gears. Hence, this is said to present a "crossed-belt" analogy for the action of the gears. However, since the gear action functions with a push of driving teeth against driven, it is evident that the gear driving action is on the slack side of the belt.

Now, looking down on the axis formed by the line of centers from O_2 to O_1 , assume axis O_2 rotated about this vertical axis counterclockwise through an angle of 60 deg. Fig. 3 then shows the

new disposition of the axes.

The two driving ribbons of action, emanating from each base cylinder and extending through the pitch line, which form one continuous ribbon in Fig. 6, now intersect in a single line of action in space which is tangent to each base cylinder at an interference point I and is normal to a base helix on each base cylinder. This line coincides with the common surface normal passing through the point of tooth contact of two crossed helical gears in mesh. The outside cylinders of the two gears intersect this line at limit points L_1 and L_2 .

Hence, there is a crossed-string analogy for the action of crossed helical gears similar to the crossed-belt analogy for gearing with parallel axes. The similarity extends to the fact that the gear drive is on the slack side of the string. A segment of this string, seen in plan view, is shown in Fig. 7a, which shows limit points L_1 and L_2 , and interference point I_2 . Interference point I_1 lies on the other side of O from I_2 , and is too far away to be shown.

Now let axis O_2 of Fig. 7a be raised above axis O_1 an additional distance ΔC . This changes the gear set from class 1 to class 3. The segment of string stretching from one base cylinder interference point to the other obviously must lengthen.

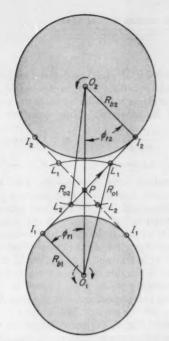


Fig. 6—Defining base circles and line of action for a conventional spur or parallel helical-gear pair.

It does so by an axial shift, Δx , of each interference point away from the skew axis. Since the line of action remains in a plane normal to the pitch helix, this means that the normal plane containing the line of action shifts parallel to itself. The condition is shown in Fig. 7b, where the line through L_2 , L_1 and I_2 is both a projection of the line of action in the plane of the paper and an edge view of the aforementioned plane. The intercepts of this plane with the axes are Δx_1 and Δx_2 and its offset from the skew axis is E.

The change in center distance just described is positive in sign, resulting in positive values for E and Δx , Fig. 8a. A negative change in center distance brings with it negative values for E and Δx , and the resulting diagram is like Fig. 8b.

The complete action diagram for crossed helical gears is made up of three views—a plan view and

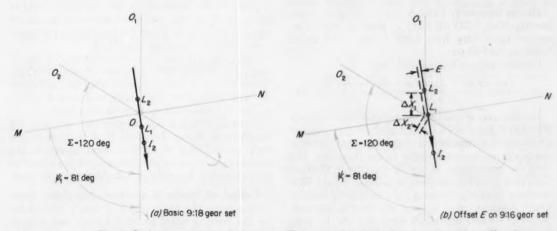


Fig. 7—Basic gear set (class I) has zero offset line of action; class 3 gear set has offset E.

a transverse view of each gear. From such a complete diagram equations may be derived for Δx , E, y_L , and y_I , making it possible to draw the plan view exclusive of the other two. These equations are

$$\Delta x = rac{\Delta C \csc \Sigma}{ an \phi_{tM}}$$
 $E = \Delta x_2 \cos \psi_2$ $y_L = \Delta \rho \cos \phi_t$ $y_I = R_b \sin \phi_t$

The procedure, after drawing the axes and the common tangent line MON, is to locate a point on MN at a distance E from O. Plus and minus directions are shown in Fig. 8a. Through this point a line perpendicular to MN is drawn. This line then represents both an edge view of the normal plane containing the line of action and a projection in the plane of the paper of the line of action itself. Limit points L and interference points I are located on this line by measuring out perpendicular to the axes distances y_L and y_I .

As shown in Fig. 9, the point I_1 lies far removed from the contact segment L_1L_2 of the line of action. This is true for every combination considered in the example. Therefore, only I_2 need be watched for its position relative to L_1 and possible involute interference. Further, Fig. 9 shows that the line of action slopes upward from I_1 to I_2 , inclined to the plane of the paper at the normal pressure angle, ϕ_n . Therefore, the true length of contact along the line of action is not shown by L_2L_1 but by L_3L_1 .

The action diagram for crossed helical gears not only shows the position of the contact segment of the line of action in relation to the interference points, but also shows the width of face necessary on each gear for the axial range of point contact over the tooth surface. This range is twice the distance from the skew axis to the projection of a limit point on the gear axis, as is shown in Fig. 10. The distance is doubled because when direction of rotation is reversed, the normal plane containing the line of action, limit points, and interference points all shift to symmetrically opposite positions with respect to the skew axis, as shown by the broken line.

Design Summary: Table 3 lists the 33 gear ratios, varying from 1.333 to 3.333 in gradual steps. The contact ratios vary from 1.050 for the 6:16 set to 1.688 for the 9:20 set.

Contact ratio, m, is computed from

$$m = \frac{(\Delta \rho_1 \sin \phi_{t1} + \Delta \rho_2 \sin \phi_{t2} - \Delta C) \csc \phi_n}{p_n \cos \phi_n}$$
(9)

Examination of this relationship reveals at a glance that for a given normal pitch and normal pressure angle, m is a function of the component of tooth overlap in a direction parallel to the skew axis. The term in parentheses in the numerator is distance L_2L_3 in Fig. 9. The complete numerator is L_3L_1 . The tendency toward shortening L_2L_3 because of oversize center distance (plus value of ΔC) may be counterbalanced by long addendum teeth and also by large transverse pressure angles. In the 6:17 set, for exam-

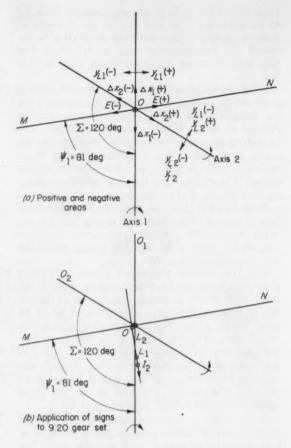


Fig. 8—Defining diagrams for positive and negative directions from follower axis.

ple, a contact ratio of 1.233 is obtained, even though the center distance is oversize by 0.341 in.

The variations from standard center distance are obtained from $\Delta C = C - 0.5$ $(D_1 + D_2)$, Table 3. Accordingly, the fixed center distance C is regarded as oversize or undersize when ΔC is positive or negative, respectively.

Table 4 lists values of $\Delta \rho$, the changes in radii of curvature in going from pitch point to tip, as for example *PL*, Fig. 6. These values apply to particular teeth, as do all the values in Table 4.

Minimum top lands, t_{no} , are 0.018 in. for the 6-tooth driver and 0.008 in. for the 16-tooth follower. The tendency is toward pointed teeth on the followers with fewer teeth than basic, and toward undercut on followers with more teeth than basic.

Pointed teeth are not objectionable on gears for speedometer drives. However, if a tooth were not only pointed, but in addition were topped in the hobbing process, then an allowance for the reduction in OD should be made in calculating contact ratio.

Layout of Tooth Proportions: Naturally, unorthodox teeth like those of Fig. 2 would be laid out on the drawing board for careful study and analysis prior to any production operations in the shop. The

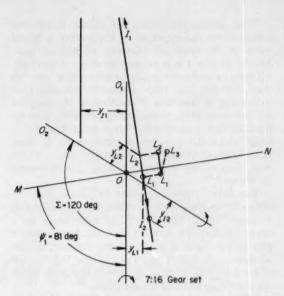


Fig. 9—Component of tooth overlap, L_2-L_{\odot} in direction parallel to skew axis.

direct and accurate way to conduct such studies is to simulate on the drawing board the movement of the hob to generate the tooth profile.

As a forerunner to such a study, however, the general appearance of series of teeth can be laid out easily and rapidly with an involute template of transparent material. All base and pitch surfaces are the same but the scale factor for each tooth is different.

Fig. 2b was made in this manner. Table 5 contains the information obtained by calculations. After the tooth profiles were established, the diagrams were enlarged or diminished proportionally to a common OD for Fig. 2a.

As drawn initially each individual tooth shows the relative location of outside circle, pitch circle, base circle, and root circle, and width to depth proportions drawn to scale. But in making comparisons of different teeth, the teeth either side of center should be transformed mentally to a common scale

Table 5—Dimensions for Tooth Profile Layouts in Transverse Section

Symbol and		Teetl			
Equation	16	17	18	19	10
$S^* = 6/D_{b2}$	9.9075	9.3247	8.8067	8.3432	7.9260
R_b	3.00	3.00	3.00	3.00	3.00
$R = R_b \sec \phi_2$	3.40	3.40	3.40	3.40	3.40
$R_o = 0.41958$	4.16	3.91	3.69	3.50	3.32
$R_r = 0.34428$	3.41	3.21	3.03	2.87	2.73
$0.5t_o = t_{no} \sec \psi_o S/2$	0.06	0.11	0.13	0.14	0.12
$m_s \uparrow = S/S_B$	1.12	1.06	1.00	0.95	0.90

* $S = Scale factor + m_s = Scale factor ratio$

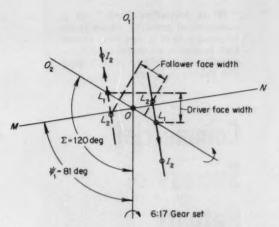


Fig. 10—Minimum face width is twice distance between skew axis and projection of limit point on gear axis.

factor S. To make this feat easier, the outside circular arc of the basic tooth is extended for a full 180 degrees. It should be realized that all outside diameters and all root diameters actually are identical, while pitch and base diameters are different.

It should be evident from the drawing of the 20tooth gear that undercut must be avoided on two important counts: 1. It cuts down on length of involute profile on a tooth that is already all dedendum, stubbed on its involute portion. 2. The fillet cuts deeper and deeper in toward the centerline of the tooth as the undercut of the profile progresses. The dotted fillet curves illustrate this, Fig. 2.

Undercut is the difference between the undercut radius R_u and the root radius R_r . The undercut radius is found from

$$R_{\rm w} = \frac{D_b \cos \phi_t}{2} - R_t (1 - \sin \phi_t) \tag{10}$$

where R_e is the edge radius of the hob. A hob edge radius of 0.010 in, was assumed for these calculations.

Thus, $R_u - R_r = -0.0155$ in. for the 20-tooth follower, Table 4. So long as this difference is negative there is no undercut. In general, undercut is critical for the follower with the greatest number of teeth.

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if an invention "sells" as a commercial product, there is an inference that it has two essential features of patentability—novelty and utility. Here's how the courts look at

Commercial Success of **Patents**

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SSENTIAL features of a valid patent are novelty, utility, and invention. Commercial success of the invention has for many years been a yardstick used by the courts in measuring two of these essentials: Novelty and utility.

Commercial success was a factor in a decision on the validity of a patent by the Federal Court of Appeals. In this case, the patent of a coin selector

was sustained against an infringer.

Said the court, "Patentable invention is a question of law. We are likewise compelled to give way in the case of doubt, to the evidence which may be drawn from the voice of the user—that is, give way to public opinion, which is shown by the way the public accepts the product and recognizes the producer. In this case there was evidence of extensive use."1

In another case, infringement was charged against the manufacturer of a patented vulcanized rubber packing for pistons. In holding the patent valid, the federal court overruled the defense of infringers that the patent owner had failed to show the quality of invention.

The decision, later quoted and sustained by the United States Supreme Court, had this to say of the feature of commercial success, "It is a fact not to be overlooked and has much weight, that the product manufactured under it went at once into such extensive public use as almost to supersede all packing made under other methods. Such a fact is pregnant evidence of its novelty, value, and usefulness and accounts for the infringement."2

However, the presence of novelty and utility, without the essential feature of invention, are insufficient in themselves to assure the inventor of a valid patent. The pitfalls of reliance on commercial success of a patented product were recently characterized

by a federal court:

"The commercial success of almost every new article which has appeared on the market in recent years is the result of intensive advertising campaigns. In fact it is a primary function of good advertising to make the public conscious of a long felt want for the first time-a process not dissimilar to starting a tradition. A conclusion of invention derived from these circumstances however, does an injustice to this modern-day art of salesmanship . . . Only where the question of patentability is close, is commercial success a makeweight factor. However, if invention is plainly lacking, success cannot fill the void."3

The federal appellate court in Illinois had occasion to construe similar circumstances surrounding a design patent. This patent had been issued for a drawer pull in the form of a curved handle and a pair of legs. Sales of approximately fourteen million of these pulls within five years of the introduction of the design served the patentee as a basis on which

to ground his claim for a valid patent.

We have recognized the general rule that in a close case commercial success may be decisive in resolving a doubtful situation. However, although commercial success in exploiting a patent may be used to resolve a doubt in favor of the patentee, it cannot be used to create a doubt, otherwise every useful and successive thing would be patentable. Where invention is plainly lacking, commercial success cannot fill the void."4

The court rested its conclusion in this case on a decision by the United States Supreme Court rendered a few years before. Here the role of commercial success and public approval as a basis for determining the validity of a patent becomes clearly

apparent.

The patent in this case covered a process which was a refinement of the ancient "lost wax" method of casting small metal articles. The process was old when Benvenuto Cellini described it in his writings four centuries ago. However, the invention brought together, for the first time, elements never before

The Federal Court of Appeals held this patent invalid for lack of invention. The inventor appealed to the United States Supreme Court, but a divided opinion held the patent invalid and disregarded

the feature of commercial success.

"The fact that this process has enjoyed considerable commercial success however, does not render the patent valid. It is true that in cases where the question of patentable invention is a close one, such success has weighed in tipping the scales of judgment toward patentability. Where, as here, however invention is plainly lacking, commercial success cannot fill the void."5

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A design guide:

Preventing Fatigue Failures

Mechanical surface treatment—shot-peening, rolling, etc.—can upgrade fatigue resistance.

Another factor is service environment, a frequent cause of reduced fatigue strength.

Part 4—Surface Treatment and Environment

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Propeller Div. Curtiss-Wright Corp. Caldwell, N. J. THE designer of parts to be stressed in fatigue has to pay far more attention to surface condition than would be necessary for a "static" design of ductile materials. In addition, special consideration must be given to the environment in which the part or structure must operate.

Whether surface hardening is done by a metallurgical process, as outlined in Part 3 of this series, or by a mechanical treatment, as discussed in this article, considerable improvement can be obtained not only in fatigue properties, but also in resistance to abrasion. However, proper methods must be used. Otherwise, the treatment can do more harm than good.

The most common problems caused by environmental conditions are: Excessive heat, corrosion, and fretting. Any or all of these may be present, and will contribute to a reduction in fatigue strength.

Surface Treatment

Surface Protection: The belief has been expressed that the surface fatigue strength of a material may be only half of that of the internal fatigue strength.¹

¹References are tabulated at end of article.

This agrees with the hypothesis that since surface grains are not surrounded by other grains, there is less resistance to slip. At an edge, where a given grain is surrounded by even fewer grains than at the surface, this could account for some of the edge effect reported by some observers.² However, in the last reference cited, the author thought that the low strength of his square specimens might have been caused by slight variations in the roughness of the sharp projecting corners, since most of the rectangular specimens failed through a fracture starting at a corner.

As further evidence of the existence of an edge effect, an improvement of 36 per cent has been reported in the long-life fatigue strength of a flat specimen of SAE 4340 steel when the edges were rounded to a relatively large radius.³ Of course, any stress raiser such as an inclusion close to an edge will reduce fatigue strength.

The surface of fatigue-stressed structural or machine parts must be carefully protected. It is clear that one important consideration in establishing a design-stress value is the deviation from surface conditions of the specimens used to establish par fatigue-strength values. These deviations may be unavoidable in some cases, and intentional in others.

Surface Finishing: It is generally believed that the effect of mechanical surface finishing (polishing, grinding, etc.) on a structural part is largely dependent on residual stresses resulting from the finishing procedure.

Grinding may have one effect on long-life fatigue strength and an opposite effect on fatigue life at higher stresses. For example, it has been found that a ball-bearing steel of hardness Rc 59, when severely ground and hand polished, had a fatigue limit about 27 per cent lower than gently ground specimens. Yet, fatigue life at a fatigue stress of 120,000 psi was four times greater. On the other hand, tests on hardened 52100 steel flat-bending specimens seem to suggest that good commercial grinding does not reduce the fatigue limit below that obtained under very gentle grinding.

In the case of fatigue strength in bending, some investigators believe that transverse grinding introduces minute scratches that act as stress raisers, whereas other investigators find no such evidence.8

It is possible that grinding, polishing, etc., cause "plastic smearing" or microscopic tearing of the surface. This either sets up residual stresses or causes microscopic stress-raising notches. It is also possible that commercial grinding results in severe heating of the metal under the wheel, causing the metal to try to expand. This compresses the adjacent metal, sometimes above its compressive yield strength, so that plastic yielding occurs. This is followed by cooling and contracting, which results in residual tensile stresses.

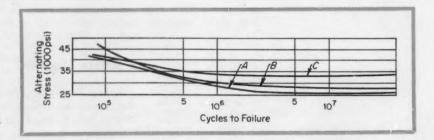
Although electrolytic polishing is not a mechanical operation, it should be mentioned, since it is sometimes used in the hope of avoiding the uncertain effects of mechanical finishing. However, there is some difference of opinion as to whether or not these effects are in fact avoided. The relative fatigue limits shown in Fig. 12 (Part 3 of this series) show that fatigue limit is consistently lower where polishing is done electrolytically rather than mechanically. On the other hand, it has been suggested that where etching is used to remove successive layers of metal, compressive stresses of 10,000 to 20,000 psi might be introduced under certain conditions.

Because of these uncertainties, where unfavorable residual stresses could develop from surface-finishing procedures, stress relief of the finished part should be called for.

Surface Hardening: Peening, rolling, etc., will cause plastic deformation of a metal. If not overdone, this sets up compressive residual stresses and may increase hardness, thereby improving fatigue properties. If only the surface layers need such hardening, shot-peening is often used. This is done by bombarding the surface with small steel shot traveling at high speed, to produce minute surface pitting.

Here again, there are differences of opinion as to why shot-peening, properly done, is capable of improving fatigue properties. In the case of shot-peened coiled springs wound from cold-drawn wire, where the failure criterion is maximum shear the influence of the compressive residual stress has been questioned. On the other hand, the opinion has also been expressed that the improvement found in torsional fatigue strength of four spring steels under test was caused by compressive residual stresses. Whatever the reason, an increase of 25 to

Fig. 15—Effect of shotpeening on fillet of SAE 1045 steel. Curve A is for the polished, unpeened steel. Curves B and C are for the steel after shot-peening with two different sizes of shot.



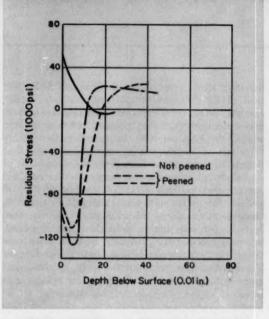


Fig. 16-Typical curves of residual stresses induced in SAE 4340 steel by shot-peening.

30 per cent has been reported in shot-peened springs of 0.9 per cent carbon manganese steel (hot-coiled in as-received condition).12 Heavier peening-to get completely below the decarburized lavers-could show an even greater improvement.

Shot-peening can improve fatigue properties, if size of shot, velocity, and time are suitable. The S-N curve¹⁸ in Fig. 15 illustrates what might happen in cases where the optimum size of shot is not used. Curve B indicates that long-life strength is improved but short-life strength is not, whereas curve C implies that the use of a different-size shot from that used for curve B resulted in little longlife improvement but a possible improvement in short-life strength. However, only two or three specimens were tested at short-life stresses, and the apparent difference between curves B and C could be due to scatter.

One of the most comprehensive studies of shot-

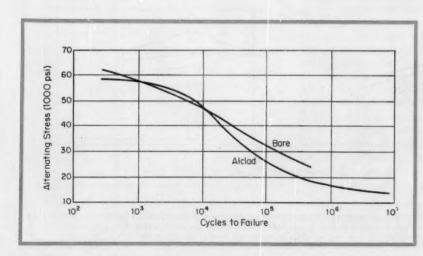
peening effects has been reported by Lessells and Broderick.14 They found significant improvement in the fatigue strength of SAE 4340 steel specimens whose surfaces were peened, then blasted with shattered glass to simulate surface damage from abrasion. Benefits became even more marked as the hardness of the steel was increased. The observers made numerous measurements of the residual stresses left in the specimens as a result of the peening. Fig. 16 shows typical curves of residual stresses found at various depths in the steel specimen.

The previous discussion has concerned steel. However, similar effects-although not necessarily of the same magnitude—have been obtained by shot-peening aluminum alloys. As a matter of fact, any material having the property of elasticity and the ability to deform plastically should respond to shot-

Rolling: This has much the same effect as shotpeening; that is, it cold-work-hardens the surface and induces compressive residual stresses. Some remarkable results from rolling have been reported in fatigue literature. For example, rolling of the fillet connecting the web and crankshaft (flake graphite iron) of an automobile, gave a 100 per cent increase18 in repeated bending-moment strength for a life of one to ten million cycles. Rolling the fillet of a stub axle showed an improvement of 35 per cent for 20,000,000 cycles, 20 per cent for 1,-000,000 cycles, and 3 per cent for 100,000 cycles of reversed-bending moment. In another case, the fatigue life of a shoulder fillet was increased 500 per cent by surface rolling.16

Although the literature contains fewer cases of rolling than of shot-peening, the instances cited here suggest that rolling should be given serious consideration, particularly in places where shotpeening is difficult to carry out.

Hammering: In places where surface effect must be



17-Comparison of curves for 2024 aluminum alloy with different surface conditions.

highly localized—particularly in gear teeth—hammering has been successfully used. However, where there is a need for controlled localizing of surface hardening and setting up compressive residual stresses in gear teeth, care should be taken that in the core of the tooth a sufficient part of the cross section remains free of hardening so that relatively low tensile stresses in the core can balance high residual stresses in the surface.¹⁷

Surface Covering (Plating, Cladding, etc.): Surface covering is sometimes used in an attempt to protect fatigue-stressed parts from the damage caused by corrosion. When corrosion is expected, design stress must be greatly reduced if the material is unprotected.

Metals are usually protected from corrosion by a coating, such as plating, cladding, etc. Some of these platings or coatings may cause a substantial loss in fatigue strength. The pure aluminum which is used to coat aluminum alloys is relatively weak in fatigue resistance, Fig. 17. However, although fatigue tests indicate a reduction—for a stress life of 500,000,000 cycles—of about 25 per cent, the elimination of intergranular or localized corrosion of the basic alloy compensates for this effect. 19

For steels, numerous coatings and platings have been used. Very little quantitative information is available in the literature, but it has been found that electrodeposits of tin, lead, zinc, cadmium, copper, or silver will, if correctly applied, improve the corrosion-fatigue resistance of steels without reducing the normal fatigue properties. However, this is not true for nickel or chromium plate.²⁰

To offset the reduction in par fatigue strength of chromium-plated steel, shot-peening before plating has been tried. Tests of this treatment of SAE 4340 steel of 200,000 and 280,000 psi ultimate tensile strength have been reported. From these tests it was concluded that shot peening prior to chrome plating is very effective in reducing the harmful effect of chrome plating on fatigue21 and that fatigue strength might even be raised above that of unplated and unpeened specimens. Similar results²² are reported in tests of SAE 4340 steel of 140,000 and 260,000 psi ultimate tensile strength, shot-peened, then cadmium-plated. Mean strength values were 7 to 10 per cent higher than those for unpeened, unplated specimens. Apparently, in both these cases peening raised the par fatigue strength, while plating lowered this value back to the original, but gave a certain amount of protection against corrosion.

Anisotropy: Anisotropy in a structural material is the property that manifests itself as a difference in fatigue strength to resist stresses parallel to the direction of rolling or forging from the strength to resist stresses that are transverse or diagonal to the direction of rolling. Considerable quantitative information is available concerning the effect of anisotropy on the static strength of various materials, but relatively little about its effect on fatigue strength. In addition, no correlation has been shown between anisotropic effects on static strength and on fatigue strength.

Most materials that are forged or rolled into bars or sheets show some anisotropy when fatigue tested. The grains are somewhat elongated in the direction of rolling or forging. In steels, the same thing happens to any impurities (inclusions) that are malleable.²⁸ Manganese sulfide inclusions, which

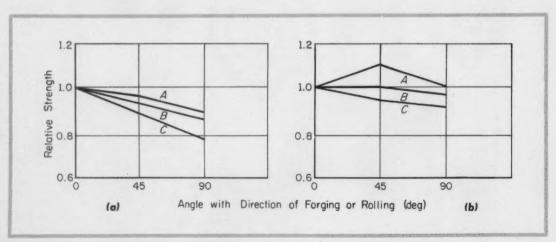


Fig. 18—Effect of anisotropy on fatigue strength of aluminum and steel alloys in, a, bending and, b, torsion. Curves A are for a steel alloy of Rc 25; B and C are for aluminum alloys 76S-T61 and 25S-T6, respectively. Tests were conducted only at 45 and 90 deg; intermediate points are not necessarily accurate.

are malleable, usually appear as stringers, whereas silicate inclusions are affected little, if at all, and retain their more or less spheroidal shape. The degree to which inclusions cause transverse anisotropy depends upon their type, shape, and size. No general reduction factor can be assigned.

Malleable, stringer-type inclusions cause a serious reduction in transverse fatigue strength. However, in SAE 4340 steel (aircraft quality high-strength steel) containing nonmalleable silicate inclusions, tests have indicated only a 5 to 10 per cent reduction in transverse fatigue strength over longitudinal strength.²² Only a 10 to 20 per cent reduction was noted in the strength of specimens cut from a large forging. This indicated that nonmalleable inclusions in present-day steels are not important causes of anisotropy. Another interesting point is that transverse anisotropy in rolled parts could very well be caused largely by the rolling itself.

These conclusions are based on anisotropic effects at 90 deg to the direction of forging or rolling. Fig. 18 shows the relative effect of anisotropy on fatigue strength at 45 deg and 90 deg for a steel and two aluminum alloys.²⁴ It is interesting to note that the right-hand chart indicates that torsional fatigue strength may be reasonably constant regardless of the anisotropic effect on fatigue bending strength. For bending-fatigue anisotropy, the values

Steeper 10 Page 10 Pag

range in the neighborhood of 10 to 20 per cent reduction, for completely transverse stressing.

In addition to the effect of anisotropy at 90 deg with the direction of rolling or forging, the effect at intermediate directions should be looked into when combined stresses occur, since the resulting principal stresses will usually act in directions between the longitudinal and transverse.

Environment

Elevated Temperature: Although this article has been limited to a discussion of fatigue properties of materials at room temperature, the fact that elevated temperatures change those properties must not be overlooked. Strictly speaking, any temperature at which a material shows a decrease in tensile and yield strength, or fatigue strength, is for that material an elevated temperature. However, most of the steels do not show such losses unless stressed while at temperatures well above 200 or 300 F. Thus, the designer need not worry about the complications of combined fatigue and creep in steels at those temperatures. However, this does not apply to the light alloys.

It should be kept in mind that at elevated temperatures, not only are fatigue stresses continuously damaging the material in a part, but creep may be adding to the damage. The relative damage differs with the material temperature, total elapsed time, and other variables.

In some cases, temperatures have been found at which fatigue stresses superimposed on creep seem to have no effect on the total service life of the material.

Corrosion: Perhaps the worst environmental condition affecting fatigue strength is corrosion. A hard steel¹⁰ having a long-life fatigue strength, under normal conditions, of 90,000 psi may lose as much as 90 per cent of that strength when tested in a stream of fresh water. As another example, marine propeller shafts are known to have very low fatigue strength and service life. Tests on the steel of marine shafts, Fig. 19, showed some small loss of torsional strength in fresh water, and almost complete loss of strength in both torsion and bending after 40 or 50 days in salt water.

Nonferrous structural materials²⁵ are not as seriously affected by corrosion as are structural steels. The so-called stainless steels, which should more properly be termed corrosion-resistant, may lose half or more of their normal strength in salt water.

As noted previously many of the protective coat-

Fig. 19—Effect of corrosion on fatigue strength of marine propeller-shaft steel. Curve A is for the steel tested under torsion in air; B, under torsion in fresh water; C, under torsion in sea water; D, under bending in sea water. Speed of the shaft during all tests was 2,160,000 cycles per day.

ings employed to reduce the effects of corrosion may reduce the par strength of a structural material. However, where the fatigue strength of unprotected materials is likely to be seriously reduced by a corrosive environment, the relatively small effect of a protective coating can usually be tolerated.

Fretting: When the surfaces of two metals are held in close contact and one of the metals is subjected to fatigue stressing, fretting occurs causing a marked reduction in fatigue strength. Cyclic stressing causes cyclic strain, and even if the relative movement of one surface over the other is as small as 0.001 in., fretting will still occur. Fretting failures are usually easy to detect because of the presence of finely divided material that has been removed from the metal surfaces by the friction and oxidized in the air.

Fatigue-strength reductions have been reported ranging all the way from 5 to 80 per cent. In one case²⁶ nine ½-in, steel shafts were tested as cantilever rotating beams. Because of fretting, their "smooth" fatigue strength for 85,000,000 cycles was reduced from about 50,000 psi to about 10,000 psi. A subcritical quenching of the steel brought the strength up to nearly 20,000 psi, presumably by setting up compressive residual stresses in the surface lavers of the steel.

Similar improvements have been obtained²⁷ by prior shot-peening of contact surfaces. Surface rolling affords a substantial improvement in fatigue strength under fretting conditions, although it does not alleviate the fretting itself. Other devices used to reduce the destructive effects of fretting are: Soft gripping pads, prior oxidation of surfaces, interposition of soft metal screens, surface plating, etc.

In tests, molybdenum disulfide, MoS2, bonded to the hot metal surface by corn syrup, was found28 to provide protection for millions of cycles of 0.001in. vibratory motion of a 1/2-in. 52100-steel sphere (surface finish 3 or 4 mu rms, against glass, under a 0.2-lb load at 7000 cpm). Similar results were obtained with two plates of Swedish steel (0.003-in. motion at 600 cpm under a 20-lb load).

The intersurface materials will, of course, wear through in time. But even the number of fatigue cycles required to wear them through is a gain over the cycle life of unprotected materials subjected to fretting.

Part 5 of this series will discuss the factors involved in calculating fatigue strength or life.

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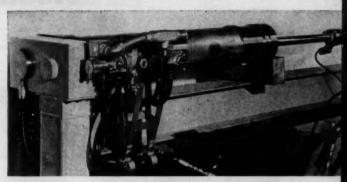
They Say . . .

"Each of us, as the handiwork of the Creator, must be creative-give of our mind, emotions, and physical being—if we are to fulfill our potentialities. And this includes concern for our fellow men. One of the effective means for satisfying this need and acting upon this concern is pursuance of the natural sciences and of research as an activity in them. Physically, through research we help to establish a better life for our fellow men. Spiritually, the receptiveness and purposefulness implicit in research strengthen our faith-in the improvability of society, and in a future that will give meaningfulness to our lives."-WILLIAM H. BROWNE, Mgr., Mechanical Engineering Dept., Battelle Memorial Institute.

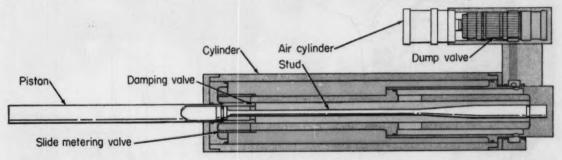
Hydraulics, Pneumatics Combine For

Snappy Acceleration Unit

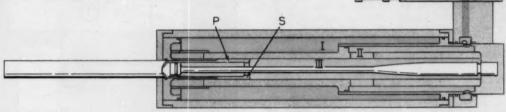
FROM 0 to 105 mph and back to 0 in less than 4 feet—that's the kind of ride an object can get if it's fastened to a new linear accelerator. The 105-mph speed can be reached by the time the object has traveled just 7 in. and can be maintained for 24 in., allowing just 8½ in. to brake it to a stop without excessive shock loads. The accelerator develops from 240 to 1000 g as a controlled function, and 760 hp on the 1½-in. OD shaft. The Linac was developed by Tayco Developments, Inc. for use in a missile test program.



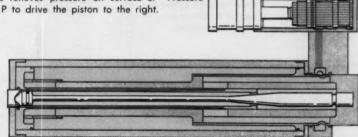
AIR-OPERATED dump valve is the key to the quick-acting accelerator. It can be fully opened in one millisecond, and dumps hydraulic fluid at a 70-gpm rate.



DIFFERNTIAL pressure areas control motion of the piston. Before actuation hydraulic pressure is applied at S and P, but S, being larger, causes the piston to remain fully extended when chambers I, II, and III are pressurized.

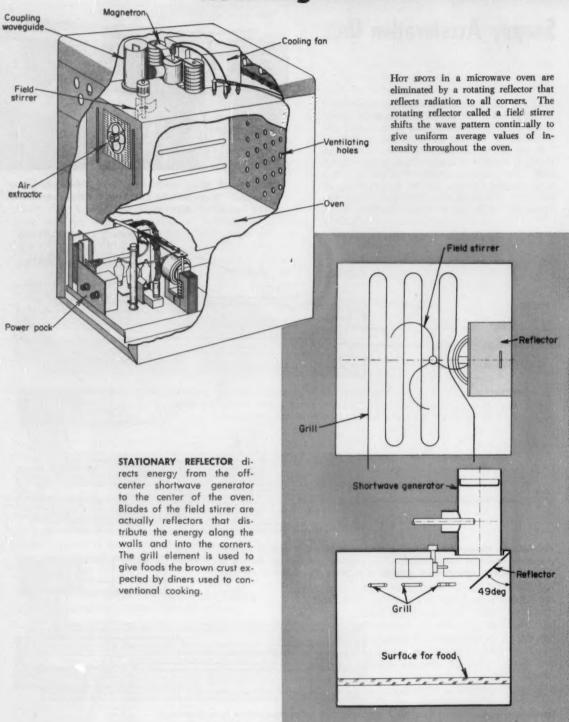


Operation is triggered by dumping fluid in chambers II and III through the pneumatically operated dump valve. This relieves pressure on surface S. Pressure from chamber I operates on shoulder P to drive the piston to the right.

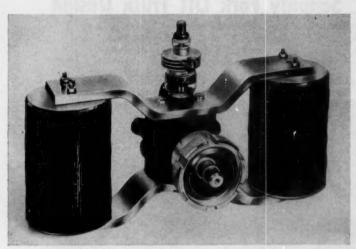


Deceleration occurs when shoulder P passes port B, relieving pressure from chamber I through the dump valve. At the same time, the tapered portion of the stud begins to restrict the annular opening of the damping valve, further decelerating the piston.

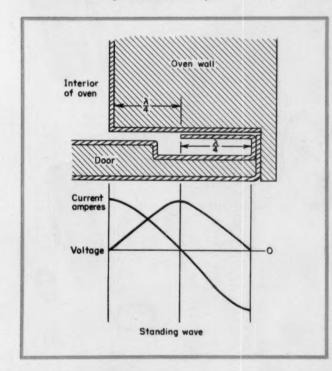
Rotating Reflector Eliminates

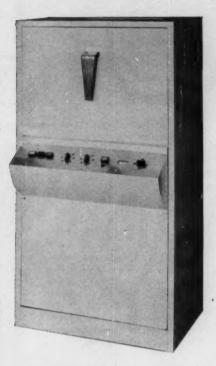


Hot Spots in Short-wave Cooker



MAGNETRON that generates shortwaves for the cooker has air-cooled cathode (top) and water-cooled anode (center). Unusual feature is a separate radiating heater for the cathode. This permits the heater to be left on for long periods while the oven is being used intermittently.





SHORTWAYE cooker with 2-kw output was displayed by NV Philips Gloeilampenfabrieken, Eindhoven, Netherlands, in Paris recently. Design of shortwave cookers was discussed by W. Schmidt in Philips Technical Review.

DOOR SEALS, which keep shortwave radiation from escaping, consist of two opposing pockets 1/4 wavelength deep. Together they form a waveguide that causes a standing wave. In the center of this standing wave, current is zero and a joint between door and oven is permissible. Contact springs, not shown, seal the outer lip of the door.

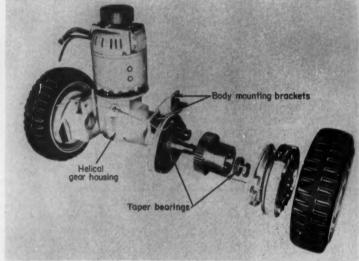


Electric lift truck called ELF is produced by Automatic Transportation Co., Chicago. Roller bearings are from Timken Roller Bearing Co., Canton, Ohio.

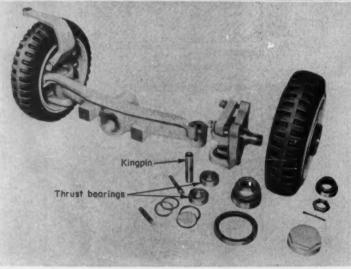
Packaged Transmission, Redesigned Steering Linkage Simplify Fork Lift Truck Design

PACKAGED gear assembly for the drive wheels of a fork lift truck is arranged to permit removal of individual gears without removing the axle. Kingpins, located within depressed wheel discs keep road shocks from being transmitted to the steering wheel.

GEARS ARE REMOVED from the drive axle by blocking up the vehicle and removing one wheel. They are supported by taper roller bearings and are driven by pinions that get power from the motor through a helical gear system.

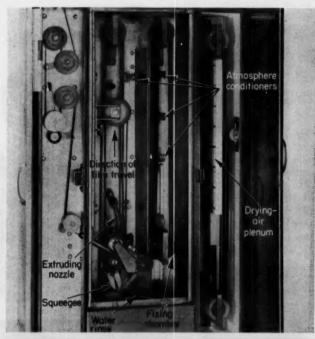


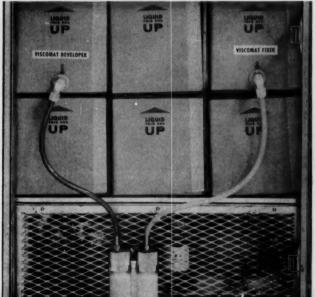
RUGGED kingpins mounted in the center of the hollow guiding wheels absorb road shocks easily. Bending and shear stresses are at a minimum on this joint. Most operating loads are transmitted as thrust stresses.



Movie-in-a-Minute Developing Machine Extrudes Viscous Developer on Film

Developing chemicals are squeezed onto film like extruded toothpaste in a 0.008-in, layer that ellows little waste. After the developer is flushed off with water, fixer is applied in the same way. Total time for developing 36 ft of film is 1 min. Fast-operating movie developer, called the Viscomat Processor, is produced by Eastman Kodak Co., Rochester, N. Y.

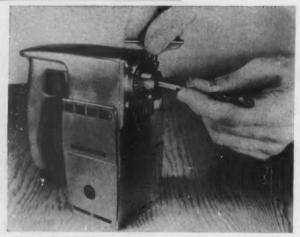






EXTRUDING hopper pinches out developer in a downward direction on an up-moving ribbon of film. The developer is evenly applied over the entire width of the film. Film is rinsed in a water jet and air dried before the process is repeated with fixer.

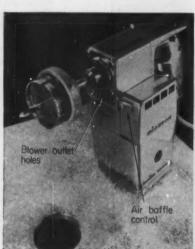
VISCOUS DEVELOPER comes in plastic-lined gallon cartons. The chemical is drawn through puncture-type probes. As the chemical is drawn off, the plastic carton liner collapses, keeping the chemical air-free until used. Chemicals are delivered to the extrusion unit through a gear-driven metering pump.



VERSATILITY and economy are improved by a spiroid gear speed-reduction stage in a new quarter-inch drill. Removing the bulk of the motor from behind the bit makes hole sighting easier. The square motor housing becomes a base on which to stand the drill or even bolt it down for sanding and buffing operations. Spiroid gearing reduces the speed in one step and permits the use of sintered gears. Chip-blower air can be cut off when not wanted.

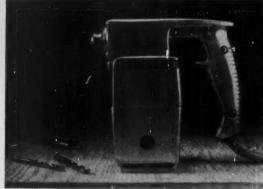
Spiroid Gears Simplify Drive in Home Shop Drill

OFFSET of the spiroid drive puts the drill point closer to one side of the motor. Advantage: Holes can be positioned closer to obstructions than with present drill designs. One-step reduction gives the bit a speed of 1800 rpm.



CONTROL for chip-blower air is a baffle plate mounted on a slide. It can be moved across outlet holes to throttle or completely cut off the stream of air to the work surface.





RECTANGULAR motor housing doubles as a stand for the drill, or a bracket to mount it for stationary use. The model D-25 1/4-in. Dirk was introduced by Disston Div., H. K. Porter Co. Inc., Pittsburgh, Pa.

Statistically, the best plot of a series of scattered data points is a least-squares line. But how good is such a line and how accurately does it reflect the true relationship between the data points? Here are some practical techniques for

interpreting

Least-Squares Lines

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Consulting Engineer Royal Oak, Mich.

EAST-SQUARES lines represent plots of the statistical relationship defined by a series of data points. As the name implies, these lines are so constructed that the sum of the squares of the distances by which individual data points deviate from the line is a minimum.

Contrary to the impression which might be gained from most statistics texts, a number of least-squares lines can be drawn through the same set of data points. Methods for calculating and constructing the statistically best line where a linear relationship is assumed (Y = mX + b) are covered in an earlier article.¹

The different least-squares lines described in the previous article can be classified into several categories according to the nature of the errors or random variables responsible for the deviations in the data points. These categories are summarized here in The Least-Squares Method.

Once the best least-squares line has been determined, a few simple additional calculations should be performed to assess its statistical significance, to establish the precision of its slope, or to obtain a measure of the accuracy with which it predicts the dependent variable from the independent variable. This article describes the statistical measures used to evaluate the least-squares line, and gives the conditions under which each measure should be used. Numerical examples illustrate the methods. As in the previous article, emphasis is on linear data; however, many of the methods are generally applicable to nonlinear data as well.

General Considerations: Accurate calculation of a

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least-squares line is ordinarily pointless unless the equation or slope of the line is to be used quantitatively—and in conjunction with one or more of the statistical measures given here. The additional calculations called for in this article are particularly simple, since all of the values required should be at hand from calculating the least-squares line.

In terms of practical engineering requirements, a least-squares line may be constructed through a set of scattered data points for one or a combination of three principal purposes:

· To demonstrate, analytically or graphically, the exist-

ence of a linear relationship between two variables. Statistical measures are:

1. Correlation coefficient.

2. Significance test of correlation coefficient.

To obtain a modulus or coefficient of proportionality between two variables. Statistical measures are:

1. Slope of the least-squares line.

2. Confidence limits on slope of line.

 To provide a specific, quantitative predicting relationship between dependent and independent variables.
 Statistical measures are:

1. Standard estimate of error.

2. Confidence limits of prediction.

Correlation Coefficient: An important statistical

The Least-Squares Method

The least-squares method (linear regression)¹ is an arithmetical procedure for determining the location and slope of the statistically best line through a series of data points assumed to represent a linear relationship between two variables. Validity of the method depends upon the assumption that the deviations are random in nature and follow the normal distribution law.

Properties of the different categories of least-squares lines are summarized here. Symbols are defined in the Nomenclature. Note that in accordance with standard engineering convention the independent variable is plotted along the X-axis.

Errors in Dependent Variable

Basic equations are:

Least-squares line,

$$Y = mX + b$$

Slope.

$$m = \frac{\overline{XY} - (\overline{X})(\overline{Y})}{\overline{X^2} - (\overline{X})^2}$$

Y intercept,

$$b = \overline{Y} - m\overline{X}$$

This case is the most common and is referred to as a regression of Y on X. The least-squares line always passes through the centroid of the data points. Coordinates of this point are the average values of X and Y.

Errors in Independent Variable

Basic equations are:

Least-squares line,

$$Y = mX + b$$

Slone.

$$m = \frac{\overline{Y^2} - (\overline{Y})^2}{\overline{XY} - (\overline{X})(\overline{Y})}$$

Y intercept,

$$b = \overline{Y} - m\overline{X}$$

This case, which is not nearly as common as the previous one, is referred to as a regression of X on Y. Here, again, the least-squares line always passes through the centroid of the data points but at a greater slope than a regression of Y on X.

Best Line Through Origin

Basic equations are:

Least-squares line,

$$Y = mX$$

Slope for regression of Y on X,

$$m=rac{\overline{XY}}{\overline{X^2}}$$

Slope for regression of X on Y,

$$m = \frac{\overline{Y^2}}{\overline{XY}}$$

This case occurs when nature of experiment or physical phenomena requires line to pass through origin. The procedure outlined does not give absolute minimum sum of squared deviations from line. As a result, the least-squares line may not necessarily pass through the centroid of the data points.

Errors in Both Variables

Basic equations are:

Least squares line,

$$Y = mX + b$$

Slope.

$$m = \theta + \sqrt{\theta^2 + k}$$

where

$$heta = rac{\overline{Y^2} - (\overline{Y})^2 - k[\overline{X^2} - (\overline{X})^2]}{2[\overline{X}\overline{Y} - (\overline{X})(\overline{Y})]}$$

$$k=rac{e_{Y}^{2}}{e_{X}^{2}}= ext{Ratio of error variances}$$

Y intercept,

$$b = Y - m\overline{X}$$

This procedure is the Lindley method. It requires knowledge or estimate of relative errors in X and Y variables. The least-squares line passes through the centroid of the data points. This line approaches regression of Y on X as k approaches infinity, and regression of X on Y as k approaches zero.

tool, the correlation coefficient, r, is widely used as an index of the "goodness of fit" between a least-squares line and the data points through which it is drawn. This coefficient can vary from +1.0 to -1.0, the sign depending only on the slope of the least squares-line, and the numerical value on the degree of data scatter. A correlation coefficient of +1.0 or -1.0 represents perfect correlation: All data points fall precisely on the least-squares line.

A value of zero indicates no correlation at all. It corresponds to one of two conditions. 1. Data points are scattered over an area symmetrical with respect to both the X and Y directions. 2. The least-squares line is horizontal.

The principal utility of the correlation coefficient is as a quantitative measure of the degree to which two variables are related. The square of the correlation coefficient, r^2 , is often referred to as the "coefficient of determination," and is equal to the fraction of the total variance (mean square deviation) of the Y data points explained by the least-squares line (Fig. 1).

The correlation coefficient can be expressed mathematically in various forms. However, the following equation is particularly convenient since many of the values required will be available from the calculation of the least-squares line (see Nomenclature):

$$r = \frac{\overline{X}\overline{Y} - (\overline{X})(\overline{Y})}{\sqrt{[\overline{X^2} - (X)^2][Y^2 - (Y)^2]}}$$
(1)

The specific quantities represented by the symbols

Nomenclature

- b = Intercept of least-squares line on Y axis
- m = Slope or tangent of least-squares line
- m' = Estimated range within which true slope of leastsquares line should fall with a given probability
- N = Number of data points
- r = Correlation coefficient
- r' = Estimate of correlation coefficient for infinite population of data points
- $S_m = Standard error of slope$
- $S_Y = Standard$ error of estimate for dependent variable
- $S_{Yi} = Standard$ error of estimate for a single value of the dependent variable
 - t = Student's statistical parameter
- X = Arbitrary value of independent variable corresponding either to any data point or to any point on the least-squares line
- \overline{X} = Average X co-ordinate of all data points
- $\overline{X^2}$ = Average of squared values of X co-ordinates of all data points
- X_i = Particular, preselected value of the independent variable from which a value, Y_i, of the dependent variable is to be predicted
- \overline{XY} = Average product of X and Y co-ordinates for all data points
 - Y = Arbitrary value of dependent variable corresponding either to any data point or to any point on the least-squares line
- \overline{Y} = Average Y co-ordinate of all data points
- Y² = Average of squared values of Y co-ordinates of all data points
- Y_i = Predicted value and confidence range of the dependent variable, corresponding to preselected value of X_i with a predetermined probability

	Ultimate Tensile Strength (psi × 10 ⁻⁸)*	Endurance Limit (psi × 10 ⁻³)*			
	X	Y	XY	X²	Y ²
1	60	24	1440	3600	576
	87	34	2958	7569	1156
	90	36	3240	8100	1296
	92	37	3404	8464	1369
	97	46	4462	9409	2116
	97	50	4850	9409	2500
	-111	39	4329	12321	1521
	113	56	6328	12769	3136
	118	55	6490	13924	3025
	132	53	6996	17424	2809
	145	67	9715	21025	4489
	153	69	10557	23409	4761
	165	76	12540	27225	5776
	169	77	13013	28561	5929
	180	80	14400	32400	6400
Sum	1809	799	104,722	235,609	46,859
Avg	$\overline{X} = 120.6$	$\overline{Y} = 53.27$	$\overline{XY} = 6,981.47$	$\overline{X^2} = 15,707.27$	$\overline{Y^2} = 3,123.9$

^{*}Note that the data have been coded, or divided by 10³, for convenience. This has no effect on statistical procedures except that the answers must be decoded by multiplying by the corresponding factors.

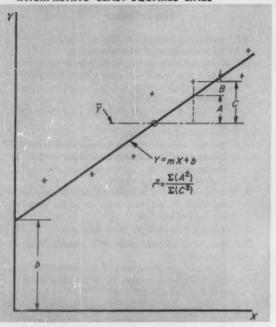


Fig. 1—Physical significance of correlation coefficient: A = explained deviation from mean, B-unexplained deviation from mean, and C-total deviation from mean.

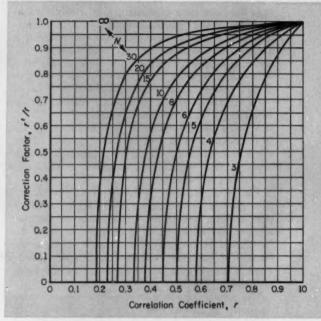


Fig. 2—Correction factor for number of data points used in calculating the value of the correlation coefficient.

are demonstrated by the arithmetical operations in the bottom line of Table 1.

Equation 1 is applicable whether the errors are in the independent variable, the dependent variable or both. This expression gives the correlation coefficient of the sample represented by the data points. When the number of data points is small, a better estimate of the correlation coefficient for the infinite population from which the sample was presumably drawn can be obtained from

$$r' = \sqrt{1 - (1 - r^2) \frac{N - 1}{N - 2}} \tag{2}$$

Fig. 2 provides the correction ratio, r'/r, in terms of the sample correlation coefficient and the number of data points. These plots show that the correction is nominal except for sample sizes less than 10 or 15, or sample correlation coefficients less than approximately 0.6.

EXAMPLE 1: Endurance limits and tensile strengths of steel are listed in the first two columns of Table 1 and plotted in Fig. 3, along with the least-squares line. From Equation 1, using the data from the bottom line of Table 1,

$$r = \frac{6981.47 - (120.6)(53.27)}{\sqrt{[15,707.27 - (120.6)^2][3123.93 - (53.27)^2]}}$$

= 0.965

No decoding is necessary here since r is dimensionless. The correlation coefficient indicates a high degree of correlation, or a close relationship, between endurance limit and tensile strength.

Significance Test: When the correlation coefficient has been calculated, a quick statistical test of its

significance is in order. This step can be accomplished by establishing the "null hypothesis" that the correlation coefficient is actually zero and that the value calculated occurred by chance alone. Student's t test can then be used to determine the probability of such an event.

Fig. 4 is derived from the Student's t distribution, and can be used directly to check the significance of the correlation coefficient. The four plots on the graph correspond to the 10, 5, 1, and 0.1 per cent significance levels. Each line is to be interpreted as the upper limit of the correlation coefficient which could occur by chance (1 time in 10, 20, 100, or 1000) when, in fact, the correlation is zero.

Example 2: Consider the data on endurance limit versus tensile strength given in Example 1 (Table 1 and Fig. 3). For 15 data points, the graph in Fig. 4 (0.1 per cent significance level) shows that the correlation coefficient would not exceed 0.75 by chance alone 1 time in 1000. The calculated correlation coefficient, r=0.965, is well above this value, yielding a very high probability that endurance limit and tensile strength are, in fact, correlated.

It should be emphasized here that correlation is not synonymous with causation. A high correlation coefficient merely indicates that the two variables are linearly related—there is no implication that one is caused by the other.

Confidence Limits on Slope: When the slope, m, of the least-squares line is used as a coefficient in a functional relationship, an estimate of the error between the slope, as calculated from the sample, and the true slope must often be obtained. First step in the estimation process is to compute

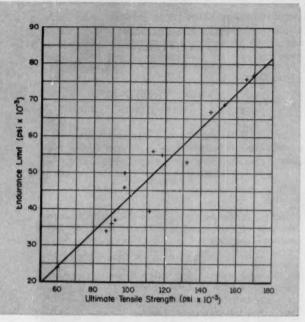


Fig. 3—Least-squares line for tensile strength versus endurance limit of steels. Data on which plot is based are given in Table 1.

the standard error (effectively, the standard deviation) of the slope. For a regression of Y on X when principal errors are in the Y-variable,

$$S_m = \frac{m\sqrt{\frac{1}{r^2} - 1}}{\sqrt{N-2}} \tag{3}$$

where

$$m = \frac{\overline{XY} - (\overline{X})(\overline{Y})}{\overline{X^2} - (\overline{X})^2}$$
(3.1)

and correlation coefficient r is given by Equation 1.

For a regression of X on Y, when principal errors are in the X-variable,

$$S_m = \frac{m\sqrt{\frac{1}{r^2} - 1}}{\sqrt{\frac{1}{r^2} - 1} + \sqrt{N - 2}} \tag{4}$$

where

$$m = \frac{\overline{Y^2} - (\overline{Y})^2}{\overline{XY} - (\overline{X})(\overline{Y})}$$
(4.1)

and, again, r is given by Equation 1.

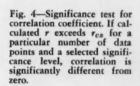
The standard error can now be used to calculate the confidence limits for the slope. These confidence limits define a band or confidence range, about the originally calculated slope, within which the true slope can be said to fall with a predetermined probability. Thus,

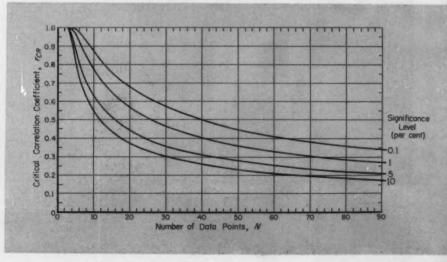
$$m' = m \pm t S_m \tag{5}$$

where the value of Student's t depends upon the number of data points and the selected probability of including the true slope within the confidence range. This probability is often set somewhat arbitrarily at 0.95 (significance level 0.05) so that there is only one chance in twenty of the true slope falling outside of the confidence range. Depending upon the circumstances, any value of probability (say, 0.90, 0.99, etc.) can be employed.

For most engineering purposes, the value of t for substitution in Equation 5 can obtained with sufficient accuracy from Fig. 5. In the use of the chart for this case, the number of degrees of freedom is N-2. The ordinate of the corresponding point on the appropriate probability curve gives the value of t.

Example 3: Thermal expansion versus temperature data for an experimental plastic are given in the first two columns of Table 2. It can be assumed here that principal errors are in the dependent variable (expansion data), and that a regression of Y on X is appropriate. From Equation 3.1, sub-





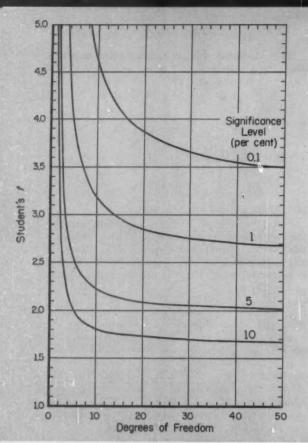


Fig. 5—Student's t as a function of degrees of freedom and significance level. Number of degrees of freedom is N-2 for conventional least squares lines, and N-1 for the best line through the origin.

stituting from the bottom row of Table 2,

$$m = \frac{4245.8 - (102.5)(37.83)}{10,804.2 - (102.5)^2} = 1.236$$

or, with units decoded, $m=12.36\times 10^{-6}$ in./in./deg F. From Equation 1.

$$r^{2} = \frac{[4245.8 - (102.5)(37.83)]^{2}}{[10,804.2 - (102.5)^{2}][1917.7 - (37.83)^{2}]}$$
$$= 0.9352$$

Substituting into Equation 3,

$$S_m = \frac{1.236\sqrt{\frac{1}{0.9352} - 1}}{\sqrt{10}} = 0.103$$

From Fig. 5, selecting the 5 per cent (0.05) significance level, the value of t corresponding to 12 data points (N-2=10 degrees of freedom) is 2.24. Thus, from Equation 5,

$$m' = 1.236 \pm 2.24(0.103) = 1.236 \pm 0.231$$

This result indicates that, with a 95 per cent probability, the true population slope will lie within ± 0.231 of the slope calculated from the data points, or between 1. 005 and 1.467.

When both variables are in error, and a technique such as the Lindley method² is used to calculate the slope of the line, no such direct procedures as those used here are available for determining the confidence limits of the slope. If confidence limits of the Lindley slope are considered necessary, the method of calculation presented by Creasy is recommended.³

Confidence Limits of Prediction: When the leastsquares line is to be used for predicting values of the dependent variable from measured values of the

Table 2—Temperature Versus Thermal Expansion

	Temperature (F)	Dilatometer Reading (in. × 10 ⁻⁵)	Reading		
17/12/20	X	Y	XY	X ²	Y ²
La Trans	75	1.0	75	5625	1
	80	14.0	1120	6400	196
	85	18.0	1530	7225	324
	90	16.0	1440	8100	256
	95	26.0	2470	9025	676
	100	40.0	4000	10000	1600
	105	40.0	4200	11025	1600
	110	43.0	4730	12100	1849
	115	57.0	6555	13225	3249
	120	69.0	8280	14400	4761
	125	70.0	8750	15625	4900
	130	60.0	7800	16900	3600
Sum Avg	$\frac{1230}{\overline{X} = 102.5}$	$\frac{454.0}{Y} = 37.83$	$\frac{50,950}{XY} = 4,245.8$	$\frac{129,650}{\overline{X}^2} = 10,804.2$	$\frac{23,012}{\overline{Y}^2} = 1,917.$

independent variable, the confidence limits of prediction become significant. These limits are calculated in a manner similar to that used previously for the slope. First step is to compute the standard error of estimate from

$$S_{Y} = \sqrt{\frac{N}{N-2} \left\{ (1-r^2) \left[\overline{Y^2} - (\overline{Y})^2 \right] \right\}}$$
 (6)

The standard error for a single estimated value (Y_i) of the dependent variable, corresponding to a particular value (X_i) of the independent variable, is then

$$S_{Yi} = S_Y \sqrt{1 + \frac{1}{N} + \frac{(\overline{X} - X_i)^2}{N[\overline{X^2} - (\overline{X})^2]}}$$
 (7)

After a probability level is selected, the confidence limits of estimate for a single value of the dependent variable are: $\pm tS_{Yt}$. The Student's t statistic is determined as before by reading the value, corresponding to the number of data points (N-2) degrees of freedom) and the selected probability level, from Fig. 5.

The confidence limits enclose a confidence range within which any single additional data point should fall with a probability equal to that for which the value of t was taken. As indicated by Equation 7, the confidence limits are different for each value of X, and are minimum for the average X value.

Example 4: To outline the complete confidence range for the data in Table 3, several calculations of tS_{Yi} should be made at various convenient values of X. These data can then be plotted and connected by a smooth curve (Fig. 6).

First step in the calculation procedure is to determine the correlation coefficient for the hardness versus tensile strength data. From Equation 1, using the data from the bottom row of Table 3, $r^2 = 0.9617$. The standard estimate of error is, from Equation 6,

$$S_Y = \sqrt{\frac{15}{13}} \left\{ (1 - 0.9617) \left[9968.14 - (99.05)^2 \right] \right\}$$

$$= 2.636$$

From Equation 7, the standard error for a single estimated value of the tensile strength, corresponding to a particular hardness, is

$$S_{Yi} = 2.636 \sqrt{1 + \frac{1}{15} + \frac{(20.42 - X_i)^2}{15[425.38 - (20.42)^2]}}$$

$$= 2.636 \sqrt{1.067 + \frac{(20.42 - X_i)^2}{126}}$$

When $X_i = \overline{X} = 20.42$, $S_{Yi} = 2.636\sqrt{1.067} = 2.720$ or, with units decoded, 2720 psi. When $X_i = 25.0$,

$$S_{Yi} = 2.636 \sqrt{1.067 + \frac{(20.42 - 25.0)^2}{126}} = 2.930$$

or 2930 psi

From Fig. 5 for a 5 per cent significance level and 15 data points (13 degrees of freedom), t=2.16. Then, the confidence limits are, $\pm tS_{Yi}=\pm 2.16$ Sy_i. Thus, for a particular value of hardness X_i , tensile strength Y_i of a piece of steel from the same sample as used for Table 3 will be, with 95 per cent probability,

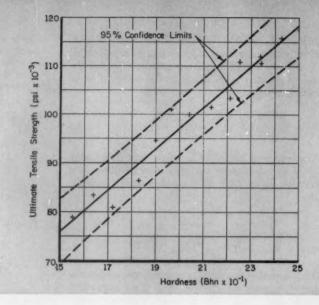
$$Y_i = mX_i + b \pm 2.16 S_{Yi}$$

where b, the Y-intercept of the least-squares line, is defined

Table 3—Hardness Versus Tensile Strength

	Hardness (Bhn × 10 ⁻¹)					
	X	Y	XY	X ²	Y2	
	15.5	79.0	1224.50	240.25	6241.00	
	16.4	83.6	1371.04	268.96	6988.96	
	17.2	81.0	1393.20	295.84	6561.00	
	17.9	88.4	1582.36	320.41	7814.56	
	18.3	86.5	1582.95	334.89	7482.25	
	19.0	94.7	1799.30	361.00	8968.09	
	19.6	101.0	1979.60	384.16	10201.00	
	20.4	100.0	2040.00	416.16	10000.00	
	21.3	101.5	2161.95	453.69	10302.25	
	22.1	103.3	2282.93	488.41	10670.89	
	22.5	110.8	2493.00	506.25	12276.64	
	23.4	112.0	2620.80	547.56	12544.00	
	23.4	110.6	2588.04	547.56	12232.36	
	24.3	115.9	2816.37	590.49	13432.81	
	25.0	117.5	2937.50	625.00	13806.25	
Sum Avg	$\overline{X} = 20.42$	$\frac{1,485.80}{\overline{Y}} = 99.05$	$\frac{30,873.54}{\overline{XY}} = 2,058.24$	$\frac{6,380.63}{\overline{X^2}} = 425.38$	$\frac{149,522.06}{\overline{\mathbf{y}^2}} = 9,968.14$	

Fig. 6-Least-squares line and 95 per cent confidence limits of prediction for hard-ness versus ultimate strength of steel. Data on which plot of least-squares line is based are given in Table 3



$$b = \overline{Y} - m\overline{X}$$

In this instance.

$$b = 99.05 - (4.243)(20.42) = 12.41$$

or, decoded, 12,410 psi. When $X_i = \overline{X} = 20.42$ (204.2 Bhn),

$$Y_i = 4.243(20.42) + 12.41 \pm 2.16(2.72)$$

or, in terms of decoded units,

$$Y_i = 99,050 \pm 5870 \text{ psi}$$

When $X_i = 25.0$ (250 Bhn),

$$Y_i = 4.243(25.0) + 12.41 \pm 2.16(2.93)$$

$$= 118,485 \pm 6633 \text{ psi}$$

Note that the confidence band in Fig. 6 encloses all 15 data points. This condition is consistent with the selection of the significance level (0.05) which gives assurance that nineteen out of twenty data points should fall within the confidence limits.

Confidence Limits for Best Line Through Origin: When the least-squares line must pass through the origin, the equation of the line is Y = mX. For a regression of Y on X,

$$m = \frac{\overline{XY}}{\overline{X^2}} \tag{8}$$

and for a regression of X on Y,

$$m = \frac{\overline{Y^2}}{\overline{XY}} \tag{9}$$

The confidence limits for the slope are calculated in the usual form: $\pm tS_m$, where Student's t is taken from Fig. 5, using N-1 degrees of freedom as the abscissa in this instance. Standard errors of the slopes, corresponding to Equations 8 and 9, respectively, are:

$$S_{m} = \sqrt{\frac{(\overline{X^{2}})(\overline{Y^{2}}) - (\overline{XY})^{2}}{(N-1)(\overline{X^{2}})^{2}}}$$
(10)

$$S_{m} = \sqrt{\frac{(\overline{X^{2}})(\overline{Y^{2}}) - (\overline{X}\overline{Y})^{2}}{(N-1)(\overline{Y^{2}})^{2}}}$$
(11)

When the best line through the origin is to be used for predicting values of the dependent variable from measured values of the independent variable, the confidence limits of prediction can again be employed to calculate the range within which additional observations should fall with a predetermined probability.

In the same manner as for the conventional leastsquares line, the first step is to compute the standard error of estimate:

$$S_{Y} = \sqrt{\frac{(\overline{X^2})(\overline{Y^2}) - (\overline{XY})^2}{(N-1)\overline{X^2}}}$$
(12)

Then, the standard error for a single estimated value, Yi, of the dependent variable, corresponding to a particular value, X, of the independent vari-

$$S_{Yi} = S_Y \sqrt{1 + \frac{X_i^2}{NY^2}}$$
 (13)

The confidence limits for a single value of the dependent variable are, as before: $\pm tS_{Vi}$, where Student's t statistic is obtained from Fig. 5 for N-1degrees of freedom and the selected probability or significance level.

REFERENCES

- C. C. Perry—"The Least Squares Method," Machine Design, Vol. 32, No. 10, May 12, 1960, pp. 210-216.
 D. V. Lindley—"Regression Lines and Linear Functional Relationships," Supplement to Journal of Royal Statistical Society, (England) Vol. 9, 1947, p. 218.
- M. A. Creasy—"Confidence Limits for the Gradient in the Linear Functional Relationship," Supplement to Journal of Royal Statis-tical Society, (England) Vol. 18, 1956, p. 65.

Simplified design calculations for

Single-Span Rigid Frames

JOHN T. CARR Jr.

Vice President Engineering Coast Engineering Co. No: folk, Va.

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ALCULATING the forces and couples in a rigid frame is complex and time-consuming because rigid frames are statically indeterminate. Usually, analysis is made by one of the conventional methods, such as the method of least work, the moment-area method, or the slope-deflection method.

These methods are powerful, but they are generally considered too burdensome for regular use in the design of single-span machine frames and structures. Moreover, since many such frames are symmetrical in shape and have few indeterminate reactions, their analysis can be simplified.

The following method is based on the use of the area under the bending moment diagram of a simply supported beam. It is applicable when the number of indeterminates does not exceed two or when the

indeterminate force, H, is involved. To solve for H, assume a vertical loading on the horizontal member such that the moment at distance x is M_0 . Thus, $M_0 = f(x)$.

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One Indeterminate Force: Fig. 1 shows a single-

By the principles of energy storage within an elas-

Nomenclature

- $A_M = \text{Area}$ under bending-moment diagram of simple beam, lb-in.²
 - E = Modulus of elasticity, psi
- H = Horizontal reaction at base end of vertical member, lb
- $I_{GA} =$ Moment of inertia of section of vertical member,
- $I_{AD} = M_{OMent}$ of inertia of section of horizontal mem-
- $K = \frac{\text{ber, in.}^4}{\text{Constant}}$
 - $= I_{AD}h/I_{GA}l$
- M = Bending moment in beam, with subscripts to define section, lb-in.
- R = Vertical reaction at base end, with subscripts to define position. Ib
- U = Internal strain energy, in.-lb
- h = Height of vertical member, in.
- l = Length of horizontal member, in.
- x = Co-ordinate for horizontal distance from left vertical member
- y =Co-ordinate for vertical distance above base
- 8 = Deflection of beam, in.

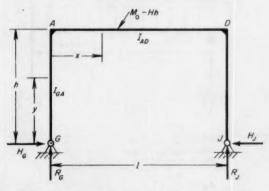
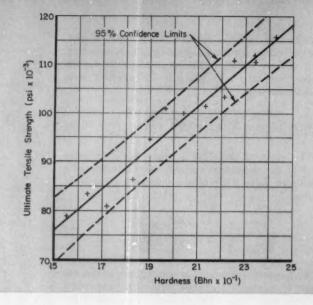


Fig. 1-Single-span rigid frame hinged at the supports.

Fig. 6—Least-squares line and 95 per cent confidence limits of prediction for hardness versus ultimate strength of steel. Data on which plot of least-squares line is based are given in Table 3.



$$b = \overline{Y} - m\overline{X}$$

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(12)

Then, the standard error for a single estimated value, Y4, of the dependent variable, corresponding to a particular value, X_i of the independent variable is,

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 (13)

The confidence limits for a single value of the dependent variable are, as before: ±tSy, where Student's t statistic is obtained from Fig. 5 for N-1degrees of freedom and the selected probability or significance level.

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Simplified design calculations for

Single-Span Rigid Frames

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ALCULATING the forces and couples in a rigid frame is complex and time-consuming because rigid frames are statically indeterminate. Usually, analysis is made by one of the conventional methods, such as the method of least work, the moment-area method, or the slope-deflection method.

These methods are powerful, but they are generally considered too burdensome for regular use in the design of single-span machine frames and structures. Moreover, since many such frames are symmetrical in shape and have few indeterminate reactions, their analysis can be simplified.

The following method is based on the use of the area under the bending moment diagram of a simply supported beam. It is applicable when the number of indeterminates does not exceed two or when the

number of indeterminates can be easily reduced to one or two.

One Indeterminate Force: Fig. 1 shows a single-span rigid frame with ends hinged at G and J. The dimensions and support are symmetrical; only one indeterminate force, H, is involved. To solve for H, assume a vertical loading on the horizontal member such that the moment at distance x is M_0 . Thus, $M_0 = f(x)$.

By the principles of energy storage within an elas-

Nomenclature

A_M = Area under bending-moment diagram of simple beam, lb-in.²

E = Modulus of elasticity, psi

H = Horizontal reaction at base end of vertical member, lb

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K = Constant

 $=I_{AD}h/I_{GA}l$

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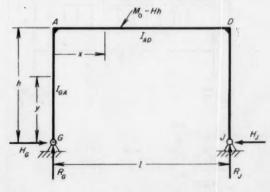
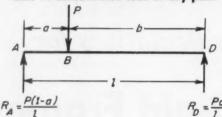


Fig. 1-Single-span rigid frame hinged at the supports.

Areas and Moments for Typical Load Conditions

Case 1: Concentrated load at any point



$$M_{\text{max}} = \frac{Pab}{l} \text{ at position } B$$

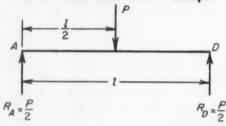
$$M_{AB} = R_A x = \frac{P(l-a)}{l} x$$

$$M_{BD} = R_A x - P(x-a)$$

$$= \frac{Pa}{l} (l-x)$$

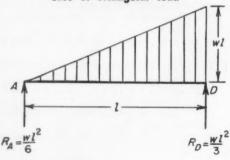
$$A_M = \frac{Pa}{2} (l-a) = \frac{Pab}{2}$$

Case 2: Concentrated load at midspan



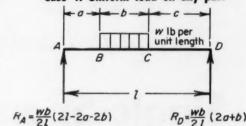
$$M_{\text{max}} = \frac{Pl}{4}$$
 at position B
 $M_{AB} = \frac{Px}{2}$
 $M_{BD} = \frac{P}{2}$ $(l-x)$
 $A_{M} = \frac{Pl^{2}}{8}$

Case 3: Triangular load



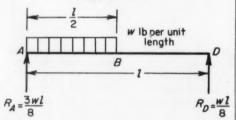
$$egin{aligned} M_{ ext{max}} &= 0.064 \ w \, l^3 \ ext{at position} \ x &= 0.5774 \ l \end{aligned} \ M_z &= rac{w \, x}{6} \ (l^2 - x^2) \ A_M &= rac{w \, l^4}{24} \end{aligned}$$

Case 4: Uniform load on any part



$$egin{aligned} \mathbf{M}_{AB} &= \mathbf{R}_{A} x \\ &= \frac{w \, b}{2 \, l} \, (2 \, l - 2 a - b) \, x \\ \\ \mathbf{M}_{BC} &= \mathbf{R}_{A} \, x - \frac{w}{2} \, (x - a)^{2} \\ \\ \mathbf{M}_{CD} &= \mathbf{R}_{A} \, x - \frac{w \, c}{2} \, (2 \, x - 2 \, a - b) \\ \\ \mathbf{A}_{M} &= \frac{w \, b}{12} \, \left[6 \, a \, c + b \, (3 \, l - 2 \, b) \right] \end{aligned}$$

Case 5: A condition of Case 4 where a=0 and b=1/2

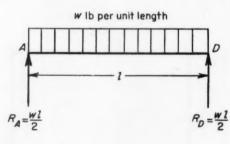


$$M_{AB} = \frac{wx}{8} (3l - 4x)$$

$$M_{BD} = \frac{wl}{8} (l - x)$$

$$A_{M} = \frac{wl^{3}}{24}$$

Case 6: Uniformly distributed load



$$M_{\text{max}} = \frac{wl^2}{8}$$

$$M_z = \frac{wlx}{2} - \frac{wx^2}{2}$$

$$A_M = \frac{wl^3}{12}$$

tic body, the strain energy stored by a bending moment in a beam-type member is

$$U = \int_{I} \frac{M^2}{2EI} dx \tag{1}$$

Only the strain energy from bending is considered because any axial and shear-strain energies are small in comparison.

Castigliano's second theorem states that the deflection 8 at any point along the member is equal to the partial derivative of the strain energy with respect to the load; hence,

$$\delta = \frac{\partial U}{\partial H} = \int_{G-J} \frac{M}{EI} \frac{\partial M}{\partial H} dx \qquad (2)$$

In Fig. 1, the moment at any distance y between G and A is,

$$M_{GA} = -Hy \tag{3}$$

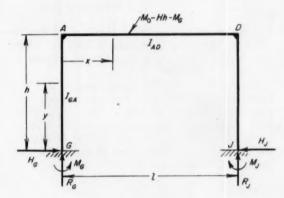


Fig. 2-Single-span rigid frame fixed at the ends.

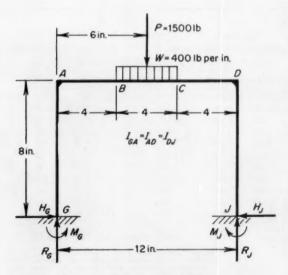


Fig. 3-Frame proportions and loading for example.

Between A and D, the moment at any point is

$$M_{AD} = -Hh + M_0 \tag{4}$$

Because of the hinged end-restraint, point G is not displaced by force H. Accordingly, Equation 2 can be set equal to zero. The range of moment M extends from G to A to D to J. Partial derivatives of Equations 3 and 4 are

$$\frac{\partial M_{GA}}{\partial H} = -y \text{ and } \frac{\partial M_{AD}}{\partial H} = -h$$

When these values are substituted into Equation 2,

$$\frac{2Hh}{EI_{GA}} \int_0^h y \, dy + \frac{Hh^2}{EI_{AD}} \int_0^l dx - \frac{h}{EI_{AD}} \int_0^l M_0 \, dx = 0$$
 (5)

The integrals of the first two terms of Equation 5 are readily evaluated. The third is the area A_M under the bending moment curve for a simple beam. Let

$$A_{M} = \int_{0}^{l} M_{0} dx \tag{6}$$

thon

$$H = \frac{3A_N}{hl(2K+3)} \tag{7}$$

where

$$K = \frac{I_{AD}h}{I_{BA}l} \tag{8}$$

This value of H can be put into Equation 4 to find the bending moment at any point between points A and D.

Moment-Area Calculation: For complex loading conditions, the maximum moment can be determined from a plot of the bending moment curve. If the curve is complex, the area under the bending moment diagram can be found mechanically with a planimeter, by graphical constructions, by approximate summations with the aid of Simpson's rule, etc.

If the bending-moment diagram is simple, the area under it can often be found by mensuration or by integration. For example, A_M of Case 2 in the tabular values is quickly verified from the area of two equal triangles.

Two Indeterminates: Fig. 2 illustrates a single-span rigid frame in which the usual three indeterminates reduce to two, H_G and M_G . The ends are fixed. The dimensions and loading are symmetrical so that $H_G = H_J$, $M_G = M_J$, and $R_G = R_J$, one-half the applied vertical load.

The equations that apply under these conditions are

$$H = \frac{3A_M}{hI(K+2)} \tag{9}$$

$$M_A = -\frac{A_M}{l(K+2)} \text{ or } M_A = -\frac{Hh}{3}$$
 (10)

$$M_{AD} = -\frac{2}{3}Hh + M_0 \tag{11}$$

If the loading is not symmetrical and R_G is indeterminate, then the force H can be determined by using Equation 9 but M_G is indeterminate unless an equation involving R_G can be solved. Since Equation 6 is a function of R_G , the area method cannot be used for solving the moments in the vertical or horizontal members even though the reaction H can be found. Methods of analyses when any number of indeterminates are involved are readily available in engineering literature.*

Example: A frame made from 2-in. standard pipe has the dimensions and loads defined by Fig. 3. The ends are fixed, Find the maximum stresses.

SOLUTION: Subscripts 1 and 2 identify the calculations pertinent to the concentrated and distributed loads, respectively. The area under the bending moment diagram for the concentrated load (Case 2) is

$$A_{M1} = \frac{Pl^2}{8} = \frac{1500(144)}{8} = 27,000 \text{ lb-in.}^2$$

Area under the bending moment diagram for the uniformly distributed load (Case 4) is

$$A_{M2} = \frac{400(4)}{12} [6(4)(4) + 4(36 - 8)]$$

*C. H. Norris and J. B. Wilbur-Elementary Structural Analysis, Second edition, 1980, McGraw-Hill Book Co. Inc., New York, N. Y.

Total area is $A_M = A_{M1} + A_{M2} = 27,000 + 27,733 = 54,733$ lb-in.² From Equation 9,

$$H = \frac{3(54,733)}{8(12)(2.667)} = 640.6 \text{ lb}$$

As a simple beam, the maximum bending moment in section AD occurs at midspan; hence, for the concentrated load

$$M_1 = \frac{1500(12)}{4} = 4500 \text{ lb-in.}$$

and for the uniformly distributed load,

$$M_2 = \frac{400(4)(12)}{4} - \frac{400}{2}(6-4)^2$$

so that $M_0 = 4500 + 4000 = 8500$ lb-in. By Equation 11, the total moment is

$$M_{\rm max} = -\frac{2(640.6)(8)}{3} + 8500 = 5083 \, {
m lb-in.}$$

A section of 2-in. standard pipe has an area of 1.075 in.² and a section modulus of 0.561 in.³ Thus, the maximum unit bending stress at midspan is 5083/0.561 = 9061 psi.

The maximum stress in vertical member GA is a combined stress from axial load and bending. The compressive stress of the axial load is (750 + 800)/1.075 = 1440 psi. The stress from bending is 2Hh/3(0.561) = 2(640.6)(8)/1.683 = 6091 psi. Hence, the maximum compressive stress in vertical member GA is 1440 + 6091 = 7531 psi.

Tips and Techniques

Angle of Twist of Tapered Shaft

The following equation gives a reasonably accurate value for the angle of twist of a tapered shaft under torsional load:

$$\phi = AB \frac{M_t L}{D^4}$$

Where the preceding equation is not sufficiently accurate, an exact value can be obtained from

$$\phi = rac{32}{3\pi} \left(rac{m^2 + m + 1}{m^3}
ight) rac{M_t L}{G D^4}$$

In these equations, $\phi = \text{Angle of twist, deg;}$ $M_t = \text{Torque, lb-in.; } L = \text{Length of shaft, in.; } D = \text{Diameter of shaft at large end, in.; } D_t = \text{Diameter of shaft at small end, in.; } m = D_t/D; G = \text{Modulus of rigidity, psi; } A, B = \text{Constants.}$

For steel, A = 1; wrought iron, A = 1.2; brass, A = 2.4; aluminum, A = 3. Values of B, for given values of m, are given in the following table:

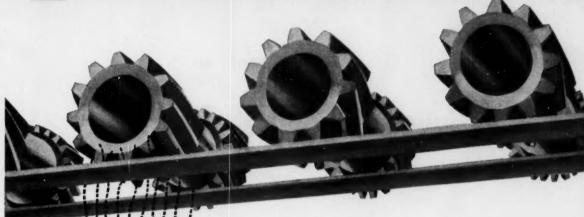
				-	
m	В	m	В	m	В
1.0	0.486 x 10 ⁻⁴	0.78	0.816 x 10 ⁻⁴	0.56	1.730 x 10 ⁻⁴
0.98	0.506	0.76	0.863	0.54	1.886
0.96	0.528	0.74	0.915	0.52	2.064
0 94	0.551	0.72	0.972	0.50	2.270
0.92	0.576	0.70	1.035	0.48	2.507
0.90	0.603	0.68	1.105	0.46	2.784
0.88	0 631	0.66	1.182	0.44	3.109
0.86	0.662	0.64	1.268	0.42	3.493
0.84	0.696	0.62	1.363	0.40	3.951
0 82	0.733	0.60	1.471	0.38	4.504
0.80	0.773 x 10~4	0.58	1.592 x 10 ⁻⁴	0.36	5.176 x 10 ⁻⁴

-HWACHII LIEN, Philadelphia, Pa.

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Detects without touching ...sensor never wears out!

Honeywell Proximity Switch detects metal within ½ inch of the sensor—over 600 operations a minute!

Protect your products and your budget! This amazing new switch is the perfect answer where rough parts or corrosive atmosphere may damage a mechanical switch, or where the delicate finish of a product may be marred by physical contact. And think of the savings you'll realize with a sensor that has no moving parts to wear out—a sensor that need never be replaced!

The Honeywell sensor has a rugged stainless steel face. The sensing unit is sealed against cutting oils, water and humidity, sand and dust; can operate submerged if necessary.

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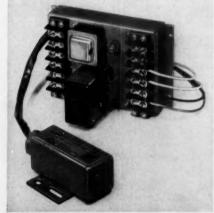
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Effects of lubricants on

Fatigue Life of Ball Bearings

E. A. BANIAK and G. A. KOHL

Texaco Research Center, Beacon, N. Y.

INDER normal conditions ballbearing failures are caused by continuous repetition of stresses or, simply, fatigue. To obtain long bearing life, high-grade materials are used together with extremely accurate design and manufacture, eliminating one fatigue factor. Other primary factors which affect bearing life are the magnitude and frequency of stress occurrences or, simply, load and speed. Available data show that ball-bearing fatigue life varies inversely with speed. It is also well established that ballbearing fatigue life varies inversely as the third to fourth power of the

Although the effects of load and speed have been well established, the effects of temperature, lubricant viscosity, types of additives, and methods of lubricant application have not been precisely defined. This article reports test details and results for these lesser-known variables. The purpose of this work was to design and build a simple ball-bearing life tester that would yield maximum results in minimum time, and to use this tester to determine the effects of practical lubricants and additives on bearing fatigue life.

Equipment: A test bearing shaft and load assembly for the bearing life tester is shown in Fig. 1. The assembly is symmetrical about the vertical center line shown. Five such

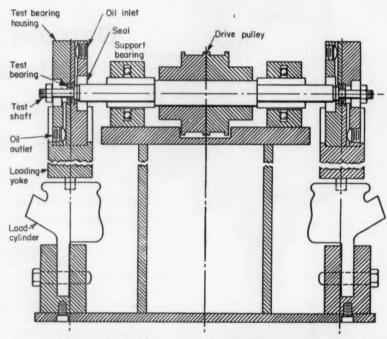


Fig. 1—Ball-bearing fatigue-life test assembly in which test bearings have ½-in bore, ½ in OD, and eight 3/32-in balls. Piston area of the load cylinder is 1 sq. in. Hence, actual load transmitted equals applied hydraulic pressure. A motor-overload tripping device stops the motor when an overload (bearing failure) occurs. Sensitivity of the overload device is such that an increase of 1 amp stops the drive motor. Oil mist is applied through bearing housings. Flood lubrication is also provided.

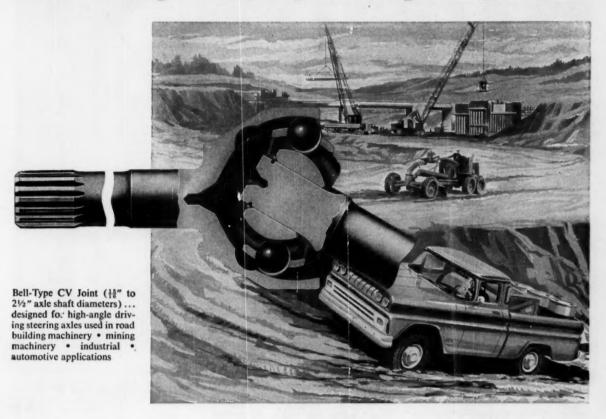
assemblies—which receive ten test bearings—comprise a complete testing machine.

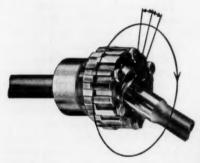
Procedure: All of the fatigue life tests were conducted with a radial bearing load of 100 lb, a speed of 1725 rpm, and without temperature control. Thermocouples located at the load side of the test bearing

outer race indicated temperatures of approximately 100 F. To insure correct loading during the test, a pressure switch was used to shut down the test if the load decreased by more than 10 lb. Bearing failure usually consisted of a complete breakup of one or more balls, creating a seizure.

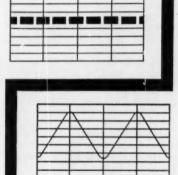
When oil-air mist lubrication was

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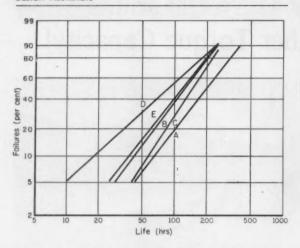


Fig. 2—Life of ball bearings (R-4 type) at 1725 rpm and 100lb load with five different lubricants applied in the form of oil-air mist.

Table 1-Bearing Life in Mist Lubrication

Oll	Viscosity		Life (hr)
	(SUS)	At 10% Failures	At 50% Failures
A	300	66	200
C	300	57	150
В	300	42	130
E	670	38	125
D	620	18	92

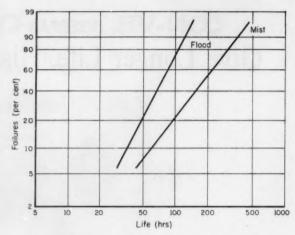


Fig. 3—Life of ball bearings (R-4 type) at 1725 rpm and 100-lb load with one lubricant applied as a flood and as a mist.

Table 2—Bearing Life in Mist and Flood
Lubrication

Oll		Bearin	g Life (hr)-			
	At 10%	Fallures	At 50%	At 50% Failures		
	Mist	Flood	Mist	Flood		
A	66	39	200	80		
C	57		150			
В	42	30	130	64		
E	38	21	125	53		
D	18		92			

used, the venturi adjustment was set to provide maximum oil flow for a mist-line pressure of approximately 2 psi. This setting was sufficient to keep the bearings in a continually wet condition.

When the force-feed lubricator was used, the lubricant flow rate was adjusted to give five drops per minute. This is equivalent to an average flow rate of 0.3 oz per hr per bearing.

Failed bearings were replaced individually as failures occurred. After nine of the ten original bearings had failed, the test was stopped. Bearing load used during the fatigue life tests was selected to give an average life of about 100 hr. The particular bearings used in these tests were loaded approximately 150 per cent greater than rated load.

For graphic presentation of test results, the Weibull function appears to be particularly well suited, especially when the sample size is small. The Weibull function is a distribution of the log log of the reciprocal of the portion of the sample surviving against the log of hours to bearing failure.

Lubricants: Test lubricants were selected for their widely different base components and/or differences in viscosity. Only one additive lubricant was investigated. These oils were:

- A—Highly refined, distilled oil of approximately 300 SUS viscosity at 100 F.
- B—Highly refined, distilled, and dewaxed oil of approximately 300 SUS viscosity at 100 F.
- C-Straight distilled oil of approximately 300 SUS viscosity at 100 F.
- D—Blend of highly refined oils of different bases of approximately 620 SUS viscosity at 100 F.
- E—Blend of highly refined oils of different bases containing an additive of approximately 670 SUS viscosity at 100 F (Oil D plus an additive).

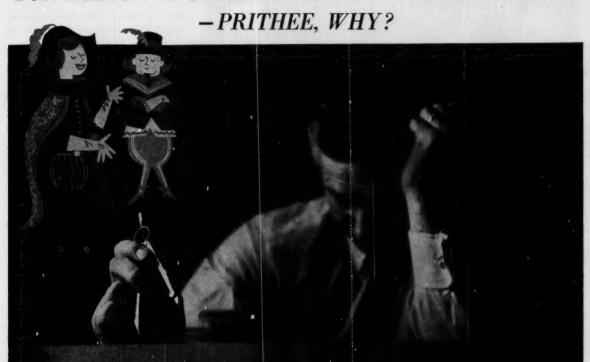
Fatigue under Mist Lubrication: All five lubricants were run in the fatigue life tester using oil-air mist lubrication. To facilitate comparison of the oils, test results are combined in Fig. 2. Oils B and D were run by an initial procedure (only 10 bearings used) while Oils A, C, and E were run by a modified procedure (14 to 18 bearing failures).

Over-all comparison is shown in Table 1.

Fatigue under Flood Lubrication: Three of the five oils (A, B, and E) were also run under flood-lubrication conditions. Typical results are compared in Fig. 3 and Table 2. In all cases, some reduction in fatigue life was obtained on the flooded-lubrication runs as compared to the mist-lubrication runs. An interesting observation is that under both mist and flood conditions, the scatter of data with Oil B was much greater than with either Oil A or E.

The apparent superiority of oilair mist lubrication over flood lubrication is counter to the belief that under heavily loaded conditions, oilair mist lubrication is less effective than lubrication by conventional methods. This would indicate that the effect of method of lubrication on fatigue life may also be dependent to a large extent on bearing size and type, and operating conditions in general. It should be emphasized, however, that instrument bearings were used in this test and that tests run on larger bear-

YON DESIGN ENGINEER HATH A WOEBEGONE LOOK



Ah, therein lies a most tragic tale. You design engineer hath created—out of his own imaginative genius, mind you—that miracle of miracles, that summum bonum—

You mean -?

Precisely. I mean a better chronodigitator.

Come, come! If this engineer hath indeed created a better chronodigitator, why doth he not sing for sheer joy, why not click together his heels just for the—uh—heck of it? Why is he woebegone?

'Tis a sad story.

Out with it, man!

Methinks his chronodigitator is too good to be true. He hath envisioned a super-chronodigitator which requires, alas, a multiple-program, adjustable cycling timer.

This super timer must be able to change program sequence and timing, in minutes with standard parts, even after installation. It must synchronize the operation of as many as twenty independent load circuits, with OFF-ON switch points field adjustable to factory standards! Yet, woe is he, its cost must not be out of this world. Now where,

Where can he find such a timer? Ahha, and possibly ho-ho! At a manufactory yelept Cramer Controls Corporation in Connecticut.

They will provide him with their Type

540 timer in any of hundreds of different speeds to give timed actuations from the first second to the twelfth-night and beyond. Plus a neat little wench—er wrench—to change cam settings and a big vernier knob to assure precise operations—within one-half of one per cent of full cycle time—right in the field. Ha! Even the actuator is adjustable!

What? I didst know this Cramer Controls Corporation as a most excellent company, unequalled for synchronous timing motors, miniature direct current motors and elapsed time indicators, but —

But me no buts! Instead, fly to yon design engineer, tell him to be woebegone no more. At Cramer he will find control magicians! A research and development group after his own heart—creative, imaginative, ingenious!

Forsooth!

Tell him if he but write, a man from Cramer will be at his desk or drawing board forthwith! A man of great savvy (prithee pardon the expression) in precisely such problems as his.

I fly!

Wait! Tell him also to write for the data-filled bulletin PB-540. Posthaste!

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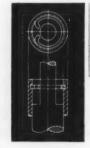
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DESIGN ABSTRACTS

ings, or under different conditions, might show flood lubrication to be superior to oil-air mist.

Observations: Some unrecognized properties of the lubricants appear to account for the major differences in bearing fatigue lives. From the data obtained on Oils A. B. and C. the effect of different base stocks of equal viscosity was apparent. The improvement of Oil E over Oil D was attributed to the additive used.

The type of bearing failures obtained with each of the five oils under both mist and flood conditions was generally the same. It was not expected that the extreme pressure or antiwear characteristics of the oils were related to fatigue life. However, the oils were evaluated by the Four Ball Mean Hertz Load and One-Hour Wear Test for comparison. It was obvious that the Hertz data could not be related to fatigue life.

ASLE Preprint No. 61 AM 4B-2, "The effect of Lubricants on Fatigue Life of Ball Bearings," presented at the 16th ASLE Annual Meeting, Philadelphia, April, 1961,

bearings

Plastic Bearings for High Loads and Slow Oscillation

W. D. Craig Jr., Mechanical Design Section, Grumman Aircraft Engineering Corp.

Characteristics of PTFE (polytetrafluoroethylene) fabric-lined bearings under high bearing loads and slow-speed oscillation, without lubrication. The investigation covers a range of loads from 5800 to 32,500 psi and testing speeds from 5 to 33 cycles per minute. Results indicate:

- · Allowable static and dynamic bearing pressure for spherical bearings lined with PTFE fabric increases with increasing bearing size.
- · Allowable static bearing pressure for sleeve bearings lined with PTFE fabric increases with an increase in bearing diameter.
- · Under conditions of constant angle of oscillation and cycle rate, PTFE fabric-lined phenolic sleeve bearings show a decrease in allowable dynamic bearing pressure with an increase in bearing diameter.

- Up to 2000 psi, the starting friction of PTFE fabric-lined bearings decreases with an increase in bearing pressure.
- Increasing the ambient temperature decreases the kinetic coefficient of friction of spherical bearings lined with PTFE fabric.
- Initial lubrication with a light mineral oil reduces the wear rate of sleeve bearings lined with PTFE fabric. Below 2000-psi bearing pressure, lightoil lubrication increases the starting friction of these bearings as compared with dry conditions.
- Spherical and sleeve bearings lined with PTFE fabric show good wear characteristics for conditions of high load and slow oscillation.

ASLE Paper No. 61 AM 6B-2, "PTFE Bearings for High Loads and Slow Oscillation," presented at the 16th ASLE Annual Meeting, Philadelphia, April 1961, 15 pp.

mechanical

Thermoelectric Generating And Cooling Devices

James D. Richards, supervisor, Thermoelectric Materials Research, Minnesota Mining and Manufacturing Co.

Applications where thermoelectric generators and coolers appear to offer the best solution, frequently the lowest cost solution, and, in some cases, the only solution.

There are several advantages which thermoelectric devices offer over conventional methods of power generation, heating and cooling. There are no moving parts, and, therefore, operation is noiseless, requiring virtually no maintenance. The shelf life is indefinitely long, and on the basis of five years continuous life tests (still in progress) service lifetime promises to be very long. The performance efficiency is practically independent of the size of the unit, a factor which favors small to medium-size units. Thermoelectric generators are versatile in that they can be made to operate from a variety of conventional heat sources, as well as nuclear reactors and radioactive isotope heat sources.

Thermoelectric devices frequently take up less space than their conventional counterparts and may weigh less. The problem areas are more severe for thermoelectric generators than for heating and cooling devices since the temperature gradi-



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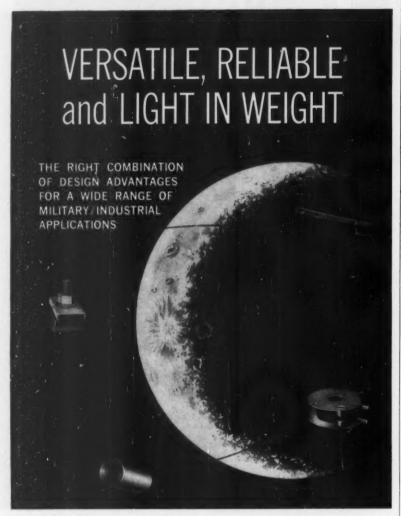
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DESIGN ABSTRACTS

ents encountered are usually greater.

"Thermoelectric Generating and Cooling Devices," presented at the American Power Conference, sponsored by the Illinois Institute of Technology, Chicago, March 21-23, 16 pp.

Design of Gears for Hobbing

M. E. Samuelson, Barber-Colman Co.

The process of hobbing and the influence it has on gear design. Throughout design, a gear designer should ask: 1. For relative dimensions, are the tolerances compatible? 2. Can I use standard tools or available tools? 3. Will our gear cutting department hold the tolerances?

In establishing compatible gear tolerances, refer to outside diameter and tooth thickness, root diameter and tooth thickness, tooth chamfer, and gear tooth thickness.

SAE Paper No. 333C, "Hobbing Versus Gear Design," presented at the SAE National Automobile Week, Detroit, March 13-17, 1961, 3 pp.

Amphibious Screw Traction Aground and Afloat

B. N. Cole, University of Birmingham, England

Inquiry into the potentialities of the Archimedean screw as a device for amphibious travel and traction. The proposal is that a hulled machine should be supported by two such screws aligned beneath the port and starboard sides, the screws being oppositely handed and counter-rotating, thus to propel the machine either aground or afloat. A major attraction of the scheme lies in the positive action to be expected of the screws when working in difficult grounds of a loose granular or semifluid nature. scheme is obviously unsuited to hard and paved surfaces. Comparisons are drawn between this and existing types of amphibious machine, with particular regard to the development of useful tractive ef-Theoretical examination of the rotor properties, for duty both aground and afloat, is supported by scale-model experimental work, and design recommendations are made. Favorable conclusions are reached, but full-scale tests would be necessary to reach a final verdict.

IME Paper No. 41/60, "Inquiry into Amphibious Screw Traction," to be published after June 30, 1961, 20 pp.

Jubrication

Aerosol Lubrication

D. G. Faust, C. A. Norgren Co., Englewood, Colo.

Development of oil-fog lubrication devices and techniques, and two fundamental design concepts concerning such devices. The differences between oil-fog lubricators employed for air actuated equipment and those used in centralized lubrication-systems for industrial machinery are discussed. System design procedures for application of oil-fog lubricators are presented and consideration is given to the future of oil-fog lubrication.

To select the proper aerosol lubricator, it is necessary to have some measure of the quantity of lubrication required. This varies from one piece of equipment to the next, depending on the number and size of bearing surfaces to be lubricated. The term "bearing inch" is the unit of measurement used for this purpose. By means of a simple calculation, the bearing-inch rating of any type of bearing surface can be established; and the total of these individual bearing-inch ratings is a measure of total lubrication requirement

ASLE Preprint No. 61 AM 2A-3, "Oil-Fog Lubrication, Past, Present, and Future," presented at the 16th ASLE Annual Meeting, Philadelphia, April, 1961, 11 pp.

electrical

Electrohydraulic Winches

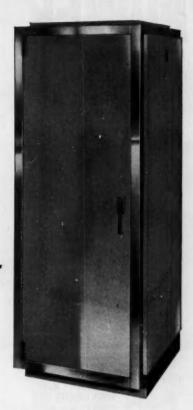
W. H. Lewis, marine division manager, Lake Shore Inc.

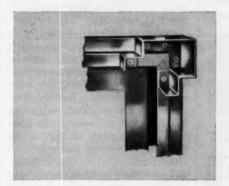
The use of ac power as a means of simulating the characteristics of dc power for cargo handling by controlling line speeds. A hydraulic transmission is powered by a nonreversing, squirrel-cage ac motor. By controlling the flow of oil between the pump or A end and the hydraulic motor or B end, either remotely or at the pump, a smooth

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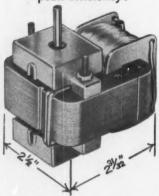
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speed control is attained that is similar, if not superior, to that of the constant-potential dc winch.

The transmission is the axial piston type. In this transmission, the ac motor drives the pump in one direction at a constant speed, and pumping action is caused by varying the piston angle relative to the shaft axis. This angle may be controlled and varied on either side of center while the pump is rotating at constant speed. The degree of angle varies the amount of output flow. The position on one side of center or the other determines the direction of flow. This permits the pump output to reverse while pistons are rotating and vary the output flow in both directions.

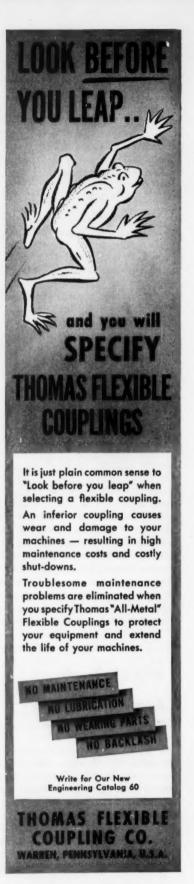
ASLE Paper No. 61 AM 4D-5, "Hydrau-lic Winches an Evaluation," presented at the 16th ASLE Annual Meeting, April, 1961, Philadelphia, 8 pp.

Applications of Engineering Magnetohydrodynamics

Ali Bulent Cambel, Gas Dynamics Lab-oratory, Northwestern University

State-of-the-art of magnetohydrodynamics. The principal applications occur in materials science, flow control, aerodynamics, containment, propulsion, and power generation. At this time there is very little data concerning plasma properties because: 1. Plasma phenomena take place at exceedingly high temperatures which present complexities in the design of measuring devices which can withstand such temperatures. 2. In many plasma and magnetogas dynamics flows, the existence of equilibrium is doubtful. This at once makes questionable the validity of measurements. In addition, the coupling of the various phenomena involved makes difficult the identification of the different causes. Further, disturbance and flow modification are brought about when probes are introduced into a flow system.

For the study of magnetogas dynamics applications, there are two basic classes of apparatus: electromagnetic shock tube and the plasma hyperthermal wind tunnel. Electromagnetic shock tubes may be utilized to great advantage in plasma diagnostics, plasma dynam-





Machine has electrical raceway built in

Plugmold raceway places outlets conveniently; houses wiring systems and other devices

More and more standard units and variations of Plugmold multi-outlet systems are being built into original equipment — such as this Hull-Standard Model 99-A Molding Press (Hull Corp., Hatboro, Pa.). This press uses two lengths of Plugmold 3000 on the frame, one as a housing for the wiring system, the other for housing pipe lines.

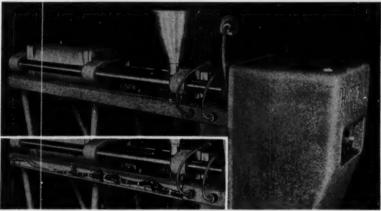
Plugmold was easily adapted for this application. Holes were drilled for three switches and two indicators located on top of the run. Plug-in, plug-out convenience is provided for the heating coils; a work light is also included. Wiring is easy to get at, simply by removing the raceway cover (see photo inset).

In the same position on the opposite side of the press, Plugmold 3600 makes a neat housing for three pneumatic pipe lines from compressor to direction control valve.

Wide choice for designers

Plugmold is made in a number of sizes, with almost unlimited choice of outlet types and spacings. Modifications of standard product engineered to meet specific or special requirements can be made; for example, factory-wired and assembled Plugmold incorporating circuit protective means on the channel (fuse or circuit breaker), portable power strips with provision for easy connect and disconnect, Plugmold wired with multi-prong jacks for control circuits, etc.

Wiremold welcomes the opportunity to assist in developing special Plugmold multi-outlet assemblies.



Plugmold on molding press holds wiring for light, indicators, heating coils, and switching.

Designing with duct:

Unique construction has hidden values

When you are designing with flexible duct, look into the extra values of Wiremold's mechanical construction (see cutaway).

While Wiremold's six standard types meet most needs, the mechanical construction permits use of other fabrics and metals. This mechanical lock does not require adhesives, assuring long life.

The metal spiral, being flat, speeds your assembly line too. Close ID tolerances assure an easy, snug fit to connectors. In seconds, duct is fastened by securing 2 or 3 drill screws through the flat spiral and connector. There's no need for clamps—or cuffed ends—although cuffs are available for those applications where quick disconnect is needed. Special shapes (e.g., square, oval) can also be furnished.





Unique mechanical construction — fabric is locked to flat metal spiral — has many advantages. For one, fast hook-ups to connectors with drill screws.

SEND FOR LITERATURE

Air Duct Plugmold





For Air Duct data, A Circle 301 on Page 19

For Plugmold data, A Circle 302 on Page 19



Payloader H-70—photo courtesy The Frank G. Hough Co.

R/M sintered friction development use-proven in over 6000 Payloaders

The Hough-built "PAYLOMATIC" P-600 full power-shift transmission utilizes a wet-friction application jointly developed by The Frank G. Hough Co., Libertyville, Ill., and Raybestos-Manhattan.

No friction failures

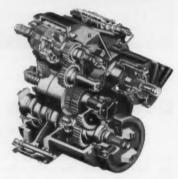
Project engineer Harry Wilson says: "We have over 6000 units in the field. There hasn't been a friction failure in the lot. The design we developed with R/M's coperation has been use-proven. We're well satisfied with R/M's ability to help design and then deliver a superior friction material at a competitive price."

Several types of materials were tested in R/M laboratories and then on Payloader tractor shovels. Sintered bronze was the material chosen for the friction plates. Plate speeds range from 1370 to 6140 rpm; gross plate pressure to 180 psi.

Unblased recommendations

Wherever you are, one of R/M's 25 sales engineers can be at your desk within 24 hours to help you tackle any friction material problem. Only R/M manufactures all types of friction materials—your assurance of unbiased recommendations!

Send for your free copy of R/M's Bulletin No. 501. It is packed with helpful engineering information. Write today.



"PAYLOMATIC" full power-shift transmission; 3-speed, fully reversing, constant mesh, countershaft type with balanced, rotating, hydraulic clutches continuously pressurefilled, cooled and lubricated.

This sintered friction plate, OD 5 34 in., is used in an oil-immersed application in "PAYLOMATIC" transmissions. The number of plates and the ratios vary between the models to meet torque requirements.





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DESIGN ABSTRACTS

ics, hypervelocity aerodynamics and magnetoaerodynamics. In electrothermal devices, the acceleration of the gas is by virtue of externally imposed steady electric fields whereas in electromagnetic devices the acceleration is due to applied electric and magnetic fields.

SAE Paper No. 312A, "Foundations of Engineering Magnetohydrodynamics," presented at the SAE International Congress and Exposition of Automotive Engineering, Detroit, January, 1961, 9 pp.

processes

Welding and Brazing Of Refractory Metals

G. M. Slaughter, Metallurgy Division, Oak Ridge National Laboratory

Important considerations confronting the fabricator of components of tungsten, tantalum, molybdenum, and columbium. Beryllium, although not a refractory metal, is included. Special considerations in the welding and brazing of refractory metals are: 1. Transition temperature. 2. Reactivity with impurities. 3. Recrystallization of parent material. 4. Porosity in welds. 5. Intermetallic formation and thermal expansion differences in brazing.

Extremely careful and detailed fabrication procedures have been developed and are considered to be necessary for producing reliable and reproducible welds and brazes in these metals.

SAE Paper No. 340E, "Welding and Brazing of Refractory Metals," presented at the Aeronautic Meeting, New York, April, 1961, 5 pp.

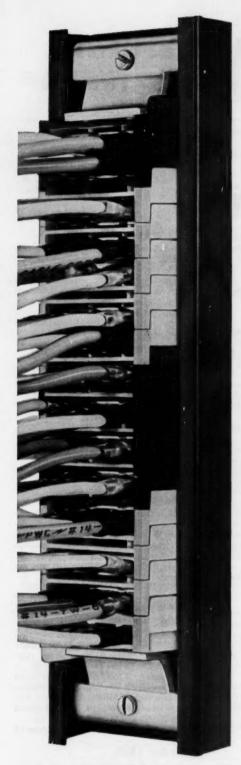
TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

American Power Conference, sponsored by Illinois Institute of Technology, 35 West 33rd St., Technology Center, Chicago 16, Ill.

ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill; papers 50 cents to members, 75 cents to nonmembers.

IME—The Institution of Mechanical Engineers, I Birdcage Walk, Westminster, London S.W. 1, England.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y., papers 50 cents to members, 75 cents to nonmembers.



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TERMI-BLOK® is a brand new concept in terminal blocks. Its design has a single, fundamental motive: to permit high-density power and control circuiting and power distribution, with no tools needed for circuit connections and changes.

TERMI-BLOK functionally replaces all terminal and barrier boards presently in use in switchboards, panelboards and power control of all kinds.

TERMI-BLOK terminal blocks provide higher density per lineal inch of aluminum track for both power and control circuits than other terminal blocks. Am TERMI-BLOK permits front-loading of circuit wires (instead of space-wasting horizontal loading) for higher overall density.

Unlike other terminal boards, TERMI-BLOK requires no tools for wiring insertions and withdrawals. Tab terminals, compression-crimped to your circuit wires by a mated AMP hand or automatic tool, can be inserted directly into 3-circuit common or 6-circuit common slotted modules, and can be extracted just as easily, without adjusting screws, bolts, etc. TERMI-BLOK will accept 10-22 AWG wire sizes, will handle 35 amps.

Write today to AMP INCORPO-RATED and receive complete specifications.



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GENERAL OFFICES: HARRISBURG, PENNSYLVANIA



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1	less machining to finish
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1	less finished weight
1	multiple coring
1	lower cost plating
1	less scrap/rejects

Send for Bridgeport's Forgings Book which describes how these major benefits can lower costs for you.

BRIDGEPORT
BRASS COMPANY

1000 Connecticut Ave., South Norwalk, Conn.

Circle 305 on Page 19

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Valves, Baffles, Traps

Bulletin 10-1 describes high-vacuum equipment, including valves, baffles, traps, and adapters. Material includes photographs, line drawings, dimensional drawings and tables of sizes. Information on adapters for valve to pump, baffle to pump, and valve to baffle connections is incorporated. 28 pages. Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

Circle 501 on Page 19

Tachometer Generators

Bulletin GEZ-3251 describes complete line of ac and dc tachometer generators and indicators. It relates information on applications, calibration, accuracy, and method of selection. Specifications, schematics, and photographs of the measurement systems described are also included. 12 pages. General Electric Co., Schenectady 5, N. Y.

Circle 502 on Page 19

V-Belt Drives

Complete instructions and engineering data are given for selection of both stock and nonstock multiple V-belt drives, Also included are specifications of standardized QD sheaves with interchangeable tapered, split bushings. More than 400 stock sheave sizes are listed in Catalog Section 50-C for A, B, C, and D-section V-belts. 64 pages. Ft. Worth Steel & Machinery Co., 3600 McCart St., Ft. Worth 1, Tex.

Circle 503 on Page 19

Bronze Bearings

Shows expanded line of miniature precision sintered-bronze Microspin bearings. Both flanged and sleeve bearings are listed in bore ranges from 0.025 to 0.3127 in. Also included in Catalog 461 are other miniature and subminiature components, including limit stops, slip clutches, gears, and shafts. 18 pages. Northfield Precision Instrument Corp., 4400 Austin Blvd., Island Park, L. I., N. V.

Circle 504 on Page 19

Polar Relays

Series PTW polar relays, small, twoposition units, provide positive on-off switching of a circuit repeatedly without readjustment. Revised Catalog 1821-E includes various types of units, and also gives information on mechanical design, magnetic circuit, coil windings, electrical characteristics, and physical dimensions. 12 pages. Industrial Products Div., Automatic Electric Sales Corp., Northlake, Ill.

Circle 505 on Page 19

Anticorrosion Treatment

Formula CRC 3-36, described in new bulletin, provides protection against corrosion for surfaces of iron, steel, aluminum, copper, brass, magnesium, and other commonly used metals. Materials are protected in production processes, in storage, and in shipment. 8 pages. Corrosion Reaction Consultants Inc., 116 Chestnut St., Philadelphia 6, Pa.

Circle 506 on Page 19

Thermoelectricity Developments

"The Coming Age of Thermoelectricity" points out the present state of this science. Specifications are given on Seejenator, a compact power package that creates electricity directly from heat. Future applications of thermoelectricity are explored in various fields. 4 pages. Harco Laboratories Inc., 77 Olive St., New Haven, Conn.

Circle 507 on Page 19

Commercial Thermostats

Commercial Types A and AY snap-acting, fixed-temperature thermostats are described in Bulletin 3000. Bulletin covers the various models, and gives information on available terminals and mountings. Ranges, ratings, and differentials also are covered. 4 pages. Stevens Mfg. Co. Inc., P. O. Box 1007, Mansfield, Ohio.

Circle 508 on Page 19

Custom Slip Rings

Describes features and gives complete technical data. Technical Data Bulletin CON-14 shows several types of slip rings offered, and lists various methods of manufacture. Chart and drawings detail manufacturing capabilities, dimensions, and tolerances. Metals & Controls Inc., Div., Texas Instruments Inc., 34 Forest St., Attleboro, Mass.

Circle 509 on Page 19

Side-Bar Chain

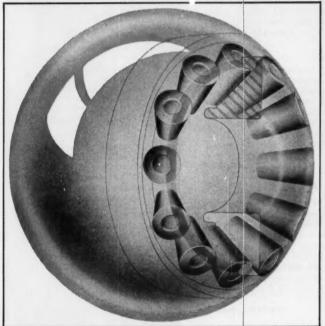
Bulletin 8 includes prices and dimensions on four most widely used sizes of offset side-bar chain. A large photograph is used to point out the features of the chain. 4 pages. Acme Chain Corp., 821 Main St., Holyoke, Mass.

Circle 510 on Page 19

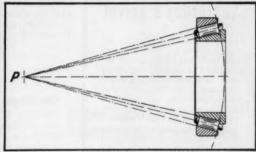
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SPHERICITY — ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.



True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. It will always roll in this one path precisely, without sliding or skewing. But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers and the raceway have a true

spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would touch all points on each roller's head!

In effect, then, each roller's taper determines the radius of a hypothetical sphere

whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

BOWER ROLLER BEARINGS

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Here is a needle valve for today's needs . . . the kind of product that only Marsh experience in both valve making and instrument making could produce . . . the one valve that gives precision throttling at any pressure—from a few pounds through 10,000 pounds.

For extra stamina and extra safety its body and stem guide are machined from solid bar stock. For greater precision, stem is accurately machined from hardened stainless steel and has fine, closely fitted threads that provide tighter shut-off; closer and more positive flow regulation. Special "Marpak" one-piece packing is long lasting and does not bind even when valves are used on higher pressures.

Marsh Needle Throttling Valves are made in a full range of sizes and patterns—either with steel bodies and stainless steel stems (type 1900) or in stainless steel throughout (type 1924).

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Eastern Easbeart Marsheuser,
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MARSH Needle Valves

Multispeed Chart Drives

Bulletin 1261 is a condensed product catalog describing multispeed chart drives, step-function speed reductors, and instrument drive systems. Five models of chart drives for use with Bristol, Wheelco, Leeds and Northrup. General Electric, and Brown recorders are described at length. Full data on eight-speed series reductor and on new ten-speed series reductor are provided. 4 pages. Insco Co., Div., Barry Wright Corp., Groton, Mass.

Circle 511 on Page 19

Silicon Rectifiers

Detailed information on the features, operational characteristics, and construction of silicon dc power supplies rated 0.75 to 75 kw. Three basic types—general purpose, essential service, and synchronous-motor field-excitation units—are covered in Bulletin GEA-7066. 6 pages. General Electric Co., Schenectady 5, N. Y. Circle 512 on Page 19

Dip Brazina

Dip brazing aluminum-fabrication technique is the subject of Brochure PD12. Publication covers the basic advantages of the method, provides data on material selection, and lists factors to consider in designing a unit to be assembled by the process. 8 pages. Precision Dipbraze Inc., 12031 Vose St., North Hollywood, Calif.

Circle 513 on Page 19

Centrifugal Pumps

Bulletin 722.4 gives complete information on high-pressure, multistage centrifugal pumps. Models 3360-3365, described, have capacities to 2600 gpm for heads to 3400 ft. Maximum working pressure is 1200 psi. Complete specifications, performance curves, materials of construction, and dimensions are given. 8 pages. Goulds Pumps Inc., 223 Black Brook Rd., Seneca Falls, N. Y.

Circle 514 on Page 19

Germanium Transistor

Type 2N1289 germanium NPN transistor, a high-speed, computer-switching unit, meets MIL-S-19500B requirements. Two pages of Publication 30.67 are devoted to a characterization of the unit by the charge-control switching concept. Also included in the bulletin are various charts of characteristics. 6 pages. Semiconductor Products Dept., General Electric Co., Liverpool, N. Y.

Circle 515 on Page 19

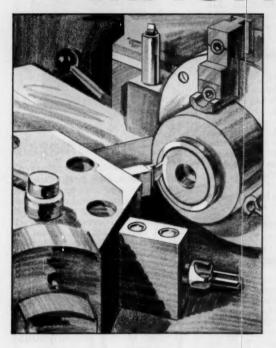
Rolling Diaphragms

Design manual for rolling diaphragms covers description, operation, advantages, applications, installation suggestions, and design data on friction-free rolling diaphragms. It also includes a nomograph for fast figuring of maximum upor-down strokes in piston applications of the diaphragms. 26 pages. Bellofram Corp., Blanchard Road, Burlington, Mass.

Circle 516 on Page 19



FREE MACHINABILITY



EATON PERMANENT MOLD GRAY IRON CASTINGS

Permits
Higher Feeds and Speeds,
Gives Longer Tool Life



Eaton Permanent Mold Gray Iron Castings are free from inclusions and hard spots, permitting higher machining feeds and speeds, and substantially increasing tool life.

The fine dispersion of graphite and dense, non-porous, homogeneous structure make this an ideal material for many difficult machining operations where high surface finish, accurate dimensional results, and sharp corners are essential. Machining of threads is clean-cut, with good surfaces and no tearing.

Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, gear blanks, valve bodies, valve plates, hydraulic components, refrigeration and air conditioning parts. Eaton Castings are produced in sizes from 1/10 of a pound to 50 pounds.

When desirable, Eaton Permanent Mold Castings can be hardened to 40-50 Rockwell "C".

CONSIDER THESE EATON ADVANTAGES

- ★ Dense, non-porous, homogeneous structure
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On these pages are shown some of the many components developed and manufactured by Westinghouse specifically for OEMs. Here is one single source for technical assistance, manufacturing and stocking of all of your electrical needs Use this total service to solve your design and manufacturing problems now. Call your local Westinghouse Sales Engineer or write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.



NEW



Black Line control transformers

Especially designed for machine tool control. Compact design plus 'Westinghouse's exclusive "BONDAR" Class "A" insulation combines quality and minimum space in Black Line Transformers. Offered in a wide range of voltage ratings—025 kva through 5 kva with a 55° C. rise. For details, write for Bulletin B-7879 to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.

HELPEUL LITERATURE

Chain-Drive Selection

Bulletin 611 provides data on Rex stock industrial chain-drive selection, and includes new ARSCM horsepower ratings. Examples of how to select chain drives are provided. 12 pages. Chain Belt Co., Milwaukee 1, Wis.

Circle 517 on Page 19

Steel and Plastic Tubing

Principal characteristics, size range, and relative cost of carbon and alloy-steel tubing for mechanical, structural, and hydraulic applications are set forth in revised Technical Bulletin 12-10. Stainless steel, aluminum, and industrial plastic tubing are also covered. Tips on when to use tubing instead of bar stock for parts production, and how to buy tubing economically, round out the data. 4 pages. Joseph T. Ryerson & Son Inc., Box 8000-A, Chicago 80, Ill.

Circle 518 on Page 19

Laboratory Oscilloscope

Bulletin A-2023 provides a detailed presentation of Type 519 high-speed laboratory oscilloscope. Designed for observation, measurement, and photographic recording of wide-band phenomena, unit displays waveforms with fractional-nanosecond rise time. Booklet contains specifications, performance characteristics, and pertinent illustrations for various high-speed measurement applications. 8 pages. Tektronix Inc., P. O. Box 500, Beaverton, Oreg.

Circle 519 on Page 19

Oil-Level Gages

Advantages of flush-mounting Type 550 oil-level gages are pointed out, and all specifications are shown with 5, 7, and 10-in. centers. 6 pages. Federal Brass Mfg. Co., Elmira, N. Y.

Circle 520 on Page 19

Bearing Steels

Bearing materials for high-temperature applications are described. Table gives nine types of steels and includes their compositions and temperature ranges. Graph shows "hot hardness" Rockwell C plotted against temperature. 4 pages. Aetna Ball & Roller Bearing Co., Div., Parkersburg-Aetna Corp., 4600 Schubert Ave., Chicago 39, Ill.

Circle 521 on Page 19

Certified Thermostats

Bulletin 3000-1 on Type A certified thermostats for electronic and avionic applications covers both hermetically sealed and semienclosed styles. Photographs, cutaway section, and line drawings of the units comprising the line are provided. Full dimensional details, ranges, tolerances, differentials, and thermostat ratings are included as well as a list of suggested uses. 4 pages. Stevens Mfg. Co. Inc., P. O. Box 1007, Mansfield, Ohio.

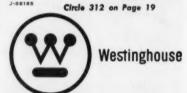
Circle 522 on Page 19

NEW



BF relay

Saves space, cuts cost, is specially engineered for machine tools. 50% less space, front accessible terminals, low temperature operation, lower installed cost, long life. In both 4-pole and 8-pole frames, rated at full load current of 6 amps/300 volts a-c 60 amp inrush. Write for Bulletin B-7345, Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.



NEW



AB-I breakers

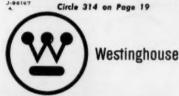
Often costless than safety switches yet are better, smaller, lighter. AB-I Breakers for motor circuit protection are installed faster, approximately half the size, ½ the weight. Machine operator can "re-set" and contacts can be visible. Write for Bulletin B-7350 and be convinced—Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.

NEW



Magnaflow electromagnetic drives

Economy, less space, 17:1 speed range or more. Includes everything needed for stepless wide-range speed control from a-c power. Has a-c motor drive, electromagnetic coupling, regulating exciter, operator control station plus variety of modifications to suit special operating conditions (1/4 to 700 hp). Write for B-7875, Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.



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TEFC d-c motor

For fastest d-c motor response! New totally-enclosed, fan-cooled Life-Line H d-c motor with 75% less armature inertia, 500% commutating ability for acceleration results in faster stops, quicker stops, faster reversing. 30 hp rating accelerates from 0 to 1750 rpm—fully loaded—in 1.1 sec.; similar response in ratings 1 to 75 hp and higher. Write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.

Prealloyed Powders

Form 128 features advantages, availability, and typical data of prealloyed stainless steel and high-alloy powders. Brochure also details the important properties of prealloyed powders now available from regular production. 4 pages. Hoeganaes Sponge Iron Corp., Riverton, N. I.

Circle 523 on Page 19

Preplated Metals

Actual samples of preplated metals with textured surfaces are featured in Crimp Metal Pak. Samples of crimps in diagonal, square, diamond, and horizontal patterns are shown with heavy plated finishes of copper as well as brass, nickel, and chromium. Also contained in the Pak is a pocket-sized, 8-page data folder giving table of properties, sheet sizes, gages and tempers, as well as fabrication information. Data also cover rigidity, reflectivity, heat diffusion, and design potentialities. American Nickeloid Co., Peru, Ill.

Circle 524 on Page 19

Air, Hydraulic Cylinders

Heavy-duty, 11/8-in. square, clamp-type cylinders are covered in Bulletin 561. Features of the Series CLH units are pointed out, and dimensional data are included. Series CLH-T for stud-mounting is also pictured, with dimensions and list of typical applications. 6 pages. Sheffer Corp., Cincinnati 15, Ohio.

Circle 525 on Page 19

Magnetic-Particle Clutch

Bulletin 6005-2 contains a simple, complete explanation of magnetic-particle and friction clutches, including cross-sectional drawings and charts. Specifically, it covers the Magneclutch, a dry magnetic-particle unit which provides flexible, regulated torque control and power transmission without chatter, grab, or wear. 6 pages. Electric Products Div., Vickers Inc., 1815 Locust St., St. Louis 3,

Circle 526 on Page 19

Hose Ends

Two new Hoz-lok hose ends are described in catalog sheets 4430A12 and 4440A12. Photograph, line drawing, and dimensions are included for each fitting. 2 pages. Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 527 on Page 19

Copper-Clad Laminates

Revised brochure includes standards for copper-clad laminated plastics conforming to the latest issue of MIL-P-13949B. Brochure contains data on ten copper-clad grades useful for printed or etched circuits. Properties of each grade are given. 6 pages. Synthane Corp., Oaks, Pa.

Circle 528 on Page 19

NEW



Rectiflow adjustable speed drives

Economical, simple, reliable, over 3:1 speed range or higher, inherent constant hp characteristics. 20 hp to 600 hp in open and totally enclosed air-cooled designs. Inherent fast response and close speed regulators make this drive a natural for a wide variety of machine tool applications. For more information, write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.

J-96169 Circle 316 on Page 19



NEW

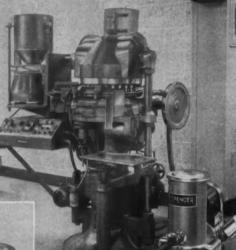


Guardistor motors

Guaranteed against burnout due to overheating from any cause! Exclusive static-semiconductors imbedded in windings respond with snap action only when windings reach critical temperature. Anticipated nuisance trips are avoided. Use full rated hp safely. Available for any size motor. Write for Bulletin B-7876 to Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.

Nothing to Sneeze at!







Thanks to SPENCER VACUUM

n equipment like these tablet forming machines, dust and spillage are more than just a nose-tickling nuisance. Unless controlled, dust can cause costly maintenance problems and can seriously hinder production.

Here, incorporation of a Spencer vacuum unit permits immediate pick up of the puff of dust which develops each time a tablet is pressed. This sensible arrangement has several advantages:

- "Down time" is reduced because dust doesn't work into moving parts.
- Health hazards are diminished.
- Production is speeded because less "clean up" is required.
- General working conditions are improved.

Perhaps a Spencer vacuum unit can improve the design of your product. For a no-obligation analysis and suggestions, write outlining your problem.



REQUEST CATALOG NO. 155B, "SPENCER VACUUM".

THE SPENCER TURBINE COMPANY HARTFORD & CONNECTICUT

Motor Application Guide

A broad line of single-phase, three-phase, and direct-current motors is described in Bulletin 010, which also includes gearmotors and selective-speed drives. Two motor-selection charts are included. Polyphase and single-phase motor characteristics are discussed, and rating and dimension tables are included. 16 pages. Century Electric Co., St. Louis 66, Mo.

Circle 529 on Page 19

Holding-Magnet Design

Bulletin titled "Short Cut for Holding-Magnet Design" explains a simplified method for designing holding magnets and assemblies. Only three factors—required pull, air gap, and geometric shape of the proposed magnet—are needed for quick, accurate design calculations. Twenty-four basic designs for holding magnets and their performance characteristics are included, as well as complete data for Alnico and Indox permanent magnets. 4 pages. Indiana Steel Products Div., Indiana General Corp., Valparaiso, Ind.

Circle 530 on Page 19

Synthetic Sapphire

Sapphire for wear-resistant surfaces, infrared and light transmission, and insulator applications is described in new bulletin. Data include properties, applications, fabrication information. 4 pages. Industrial Sapphire Co., P. O. Box 422, Quakertown, Pa.

Circle 531 on Page 19

Air-Control Valves

Series HH four-way, pilot-operated, air-control valves, offering both momentary and maintained-contact electrical-actuation, are described in Bulletin 0611-B1. Features of the units are pointed out, and two diagrams show how the main valve works. Control of the main valve by the pilot is also explained. 4 pages. Dept. 116, Hannifin Co., Div., Parker-Hannifin Corp., 501 S. Wolf Rd., Des Plaines, Ill.

Metal Coatings

Lacqua nonflammable system of protecting plated and bare metals against corrosion is described in new bulletin. Applications of the water-base coating are described in detail. 4 pages. Bee Chemical Co., 2700 E. 170th St., Lansing, III

Circle 533 on Page 19

Digital Recorder

IDR 6150 incremental-digital recorder has applications in computer programming and other fields. Pictures and specifications are included in Flyer DB-6150. 6 pages. Industrial Systems Div., Minneapolis-Honeywell Regulator Co., Beltsville, Md.

Circle 534 on Page 19



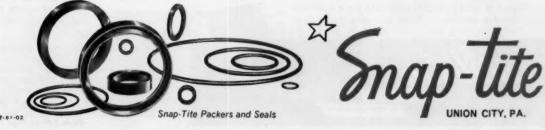
A complete choice of packers and seals permits Snap-Tite quick-disconnect couplings to handle over 600 different fluids! (some of them mighty tough)

Whatever fluid you're working with, chances are Snap-Tite couplings can handle it. Because everyone of the thousands of Snap-Tite quick-connect valved couplings comes with a wide choice of rubber packers and seals, selected according to the fluid in use. The right choice, of course, is vital for the seal is the very heart of the coupling.

To assist you in the proper selection of coupling

seal material, Snap-Tite, with the assistance of suppliers of synthetic rubber materials, has recently compiled a comprehensive Packer Usage Guide—the first of its kind in the industry.

For the Packer Usage Guide, and for complete information on the correct choice of quick-connect, quick-disconnect couplings for the fluids you use, write Snap-Tite, Inc., Union City, Pa.



K-8120 209



the secret of Ford's swing-away wheel

The secret of the new swing-away steering wheel in the Ford Thunderbird is a flexible shaft between the stub shaft in the steering gear box and the upper steering rod.

Here are the benefits derived from flexible shafts:

- 1. Safety. Safety against failures is provided.
- 2. Durability. Flexible shafts eliminate the possibility of play or lost motion at this juncture for the life of the car.
- 3. Compact. The flexible shaft is more compact than conventional joints.
- 4. Strength. In case of power steering failure, the maximum torque would be 660 pound-inches, which would occur during parking on dry pavement. The flexible shaft can absorb this and much more.

Here is another example of creative engineering with flexible shafts. Investigate for yourself how they can solve many of your design problems and at the same time reduce costs.

S. S. WHITE INDUSTRIAL DIVISION. 10 East 40th Street, N. Y. 17, N. Y.



Urethane Seals and Packings

New catalog describes and illustrates various types, sizes, operating features, and advantages of solid urethane hydraulic seals and packings. Physical characteristics of Disogrin urethane elastomer are listed. Catalog points out advantages offered by chamfered sealing lip design, also includes information on allowable seal tolerances and moving-part surface finishes than can be used. Installation requirements and procedures are also described. 8 pages. Disogrin Industries Div., Pellon Corp., 510 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 535 on Page 19

Instruments and Components

Catalog FP-1-61 briefly describes instruments and components such as electrical connectors and headers; high-temperature, radiation-resistant insulation; and insulated magnet wire and cable. Nuclear devices listed include thermocouple probes, creep capsule monitoring system, and various transducers. Scientific instruments such as the ratio digital millivoltmeter, electromicrometer, dc transducer monitor, and potentiometer ratio monitor are also illustrated and described. 4 pages. Packard Bell Electronics, 389 N. Fair Oaks, Pasadena, Calif.
Circle 536 on Page 19

Small Pumps

Bulletin 150.2 describes Type BA special-application pumps, designed for the original-equipment market. Two models are described, available in six sizes with capacities from minimum metering flow to 360 gph. Engineering data on the construction and operation of the pumps are supplemented by cutaway drawings. Rating chart lists capacities of each pump size at varying speeds and pressures, and dimensional drawings are also included. 2 pages. Moyno Pump Div., Robbins & Myers Inc., Springfield, Ohio. Circle 537 on Page 19

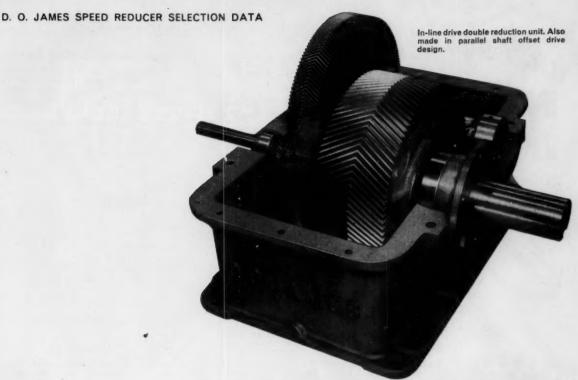
Variable-Speed Drives

New catalog features lube-free integral and fractional-horsepower variable-speed drives. Catalog is fully illustrated, and cut-away drawings and photographs are used to detail working parts. Integral and fractional modifications are illus-trated, as well as horizontal and single and double-worm assemblies. Modifications and accessories, dimensions, and technical information are also included 112 pages. Sterling Electric Motors Inc., 5401 Telegraph Rd., Los Angeles 22, Calif. Circle 538 on Page 19

Precision Resistor

User-adjusted Rotohmeter, is described in Engineering Bulletin R-65. Various forms and specifications are included. Terminal types, manner of mounting, and accessories data are given. 4 pages. Rotohmeters Inc., 46 Prospect St., Yonkers, N. Y.

Circle 539 on Page 19



for heavy loads, use <u>herringbone</u> reducers

When you require heavy-duty drive units, D. O. James herringbone gear reducers provide unequaled advantages:

Strongest tooth form — due to the arch-like construction of

Strongest tooth form — due to the arch-like construction of the tooth and large 30° helix angle.

Greatest load-carrying capacity — large multiple-tooth contact in plane of action — full width of the tooth face is utilized.

No side thrust — thrusts of the opposing helices tend to balance each other, distributing load evenly across the face of tooth. Housing is economical because no provision for side thrust need be made, nor are thrust bearings required.

Improved splash lubrication — an oil film is formed and preserved by the wedging action of the teeth.

High efficiency - 98% on single reduction units.

These reducers are made in 110 standard sizes, single, double, and triple reduction, 2:1 to 370:1 ratios, .5 to 5000 hp.

For complete information, call your D. O. James representative or write today. Ask for Catalog 40-E.

D. O. JAMES GEAR MANUFACTURING CO. 1140 West Monroe Street, Chicago 7, Illinois Since 1888, every type of cut gear and gear reducer



...where you always get good gearing



Parallel shaft offset drive triple reduction.



Parallel shaft offset drive single reduction





ELECTRIC CORPORATION

SINCE 1917-THE CHOICE OF LEADING MOTOR AND MACHINERY MANUFACTURERS

Mercury-Wetted Contact Relay

High-speed Class V mercury-wetted contact relay is for use in computers, and in data-processing and control equipment. Circular 1988 gives information on mechanical and electrical char-acteristics and physical dimensions, as well as a nomograph for determining the required contact protection. 4 pages. Industrial Products Div., Automatic Electric Sales Corp., Northlake, Ill.

Circle 540 on Page 19

Recorder-Reproducer

Bulletin A3 describes the Model 102A two-channel, analog-data tape recorder-reproducer system and its uses. Complete specifications of the system are included, as well as the extensions of these specifications that are available on special request. 4 pages. Mnemotron Corp., 3 N. Main St., Spring Valley, N. Y.

Circle 541 on Page 19

Motors, Compressors, Pumps

Line of rotary air motors, air compressors, and vacuum pumps is covered in Catalog 660. Six sizes of air motors, 1/20 to 7 hp, explosion proof and variable-speed, are described. Compressor sizes range from 0.6 to 45 cfm, to 30 psig. Vacuum pumps range from 0.6 to 50 cfm, to 28 in. Hg. Both oilless and lubricated models are discussed. 12 pages. Gast Mfg. Corp., 23065 Highway M-139, Benton Harbor, Mich.

Circle 542 on Page 19

Semiconductor Test Sets

Semiconductor test sets for use in circuit design and quality control are described. Testing of small, medium, and large transistors, diodes, zener diodes, SCRs, VJTs, switching devices, high-current SCRs, and rectifiers is covered in detail. Parameters that can be measured are also listed. 4 pages. Owen Laboratories Inc., 55 Beacon Place, Pasadena, Calif.

Circle 543 on Page 19

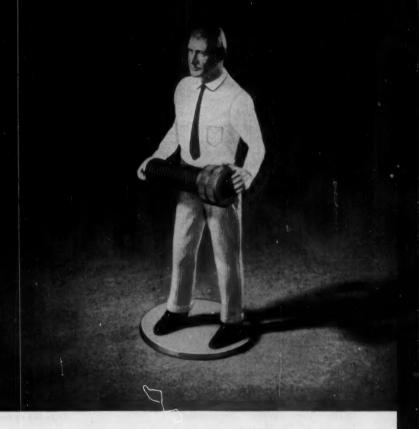
Laminated Plastics

New catalog covers industrial laminated plastics in sheet, rod, and tube form. It includes grade selection and de-scription, range of sizes, typical property values, and forms. Special section on metal-clad grades is also included. 20 pages. Write on company letterhead to Continental-Diamond Fibre Corp., Newark, Del.

Instrument Motors

Bulletin IM-1 describes the construction and operation of various different types and models of instrument motors. Included are dimensional drawings, rating charts, wiring diagrams, listings, and photographs of all units. Other sections discuss the availability of engineering service, development and testing procedures, typical applications, and application guidance. 28 pages. Write on company letterhead to Bodine Electric Co., 2500 W. Bradley Place, Chicago 18, Ill.

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To take advantage of the special knowledge that's available to you, call a Holo-Krome representative. He's an expert on top-quality Thermo-Forged's socket screws and is skilled in all phases of applying them. He'll help you design the best fastener into your product in a way that will keep manufacturing costs at a minimum.

Application assistance, same-day service and costreducing quality make Holo-Krome Thermo-Forged socket screws your best fastener buy. Like full details on how Holo-Krome quality and service can help increase your profit? See your authorized Holo-Krome distributor, or write for more information.

HOLO-KROME Thermo-Forged* SOCKET SCREWS

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS THE HOLO-KROME SCREW CORPORATION . HARTFORD 10, CONN.

A Comment



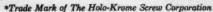












Circle 323 on Page 19

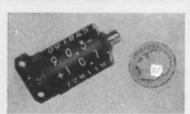
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Add-Subtract Counter

miniature unit is for instruments, computers

Low-torque instrument counter, Type 30-130, is used for digital-readout applications where plus and minus, right and left, or directional readouts are required. Counter can be driven to ±99.9, and is prevented from overrunning by built-in mechanical stops. Utilizing internal gearing, counter can be mounted on a bracket as illustrated and driven by means of a through shaft from either side. Diameter of the drums is 0.672 in.



and numerals are 0.125 in. high. Maximum torque is 0.25 oz-in. at room temperature. Running speed is 350 rpm continuous with intermittent operation at 600 rpm. Melland Gear & Instrument Co. Inc., 88-06 Van Wyck Expressway, Jamaica 18, N. Y.

Circle 544 on Page 19

Static Seal

has Teflon primary unit

Two-stage static seal has a stainless-steel V-ring seal preceded by a Teflon seal. Composite unit operates at temperatures from -65 to +600 F under pressures to 10,000 psi. Outer ring, of high yield-strength stainless steel, maintains the seal under extreme temperatures and pressures. The Teflon primary seal, permanently joined to the metal component, provides a soft seat for completely leaktight seal-



ing. The units are reusable. Seal is highly resistant to corrosion and compatible with nearly all fluids. Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 545 on Page 19

Epoxy Adhesive

cures in 60 sec at room temperature

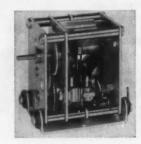
Minit-Cure formulated epoxy-adhesive system cures in 60 sec at room temperature and can be accelerated to 45 sec with use of infrared heat. Applications include bonding metal to metal, plastic to metal, plastic to plastic or any other porous or nonporous surfaces. Allaco Products, 238 Main St., Cambridge 42, Mass.

Circle 546 on Page 19

Constant-Speed Motor

is dc unit with wide range of output speeds

Speed of improved, constant-speed dc motor is magnetically linked to



reed frequency. Output-shaft speed is available as required from 1500 rpm to 1 rph or more. Built to specifications or requirements, motor is available in a wide range of operating voltages, torque, output shaft speeds, and switching arrangements. Current drain is low, permitting long operation from small batteries or other dc supply. Amglo Corp., 4327 Ravenswood Ave., Chicago, Ill.

Circle 547 on Page 19

Pneumatic Bleed Valve

withstands 14,000 psi pressure

Pneumatic bleed valve has an operating pressure of 6000 psi at temperatures from -65 to +160 F. Valve withstands pressure to 14,000 psi, and releases with 20 lb maximum.

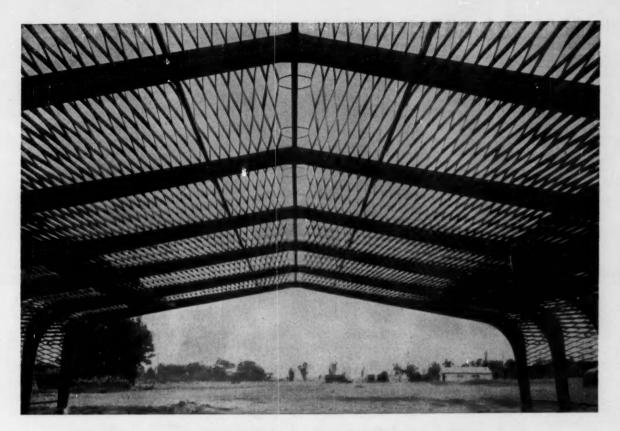


mum finger pressure at 6000 psi. Benbow Mfg. Corp., 11920 W. Jefferson Blvd., Culver City, Calif.

Instrument Differentials

provide clearance circles to ½ in. or less

Precision-balanced instrument differentials are designed especially for computers and control instruments. They provide clearance circles down to ½ in. or less, minimizing space requirements. Except where aluminum spider gears are specified,



How wood engineering helps improve lightweight roofing performance

NEEDED: a supporting structure for roof covering that could take maximum advantage of modern, lightweight roofing materials. Plastic, plastic-and-fiberglass, pressed fiber products, textiles, plywood, and light metals serve best as roofing only if supported *continuously* by the structure.

To meet this need, Gamble Brothers developed the Gambella—a lamella-type structure which provides, in effect, an expanded purlin (beam) which distributes roof loads uniformly to the framing members. This uniform loading makes possible the use of framing members of smaller dimension for equivalent loads.

Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present your design problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Louisville, Ky.



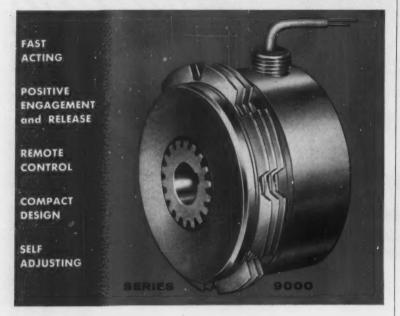


If the problem involves wood, Gamble can help!

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

IDEAL FOR AUTOMATED MACHINES



Maxitorq

CLUTCHES

Incorporating advanced design principles proved through years of service, the MAXITORQ Electric Clutch is well adapted to all types of machine drives. Simple in design . . . built to machine tool standards . . . requires no adjustments, can be used either as a clutch or brake. Disc separators not only separate discs, but also break up residual magnetism and esult in extremely fast, positive action with no drag or heating in neutral. There are few moving parts. Electrical operating unit remains stationary — hence, no troublesome slip rings, brushes, or difficult wiring problems. Operation is on standard 100 V d.c. Other voltages on special order.

If you have a clutch or brake application where you are looking for NEW and IMPROVED performance, we invite you to bring the problem to us. Phone, wire, or write Dept. MD for Bulletin No. 90.

SPECIAL FEATURES

Engaged entirely by magnetic flux.

Operate either on-off or by varying voltage for torque control.

NO troublesome slip rings or brushes.

NO levers, cams, or other highly stressed mechanical parts.

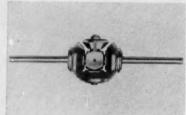
Operation is not dependent upon rotation.

Finished complete, assembled, and ready to install on shaft.



THE CARLYLE JOHNSON MACHINE CO.
MANCHESTER, CONN.

NEW PARTS AND MATERIALS



units are all-stainless steel. Each differential employs six miniature ball bearings which conform to ABEC 7 tolerance specifications. Backlash is held to 8 min or less, break-away torque from 0.1 to 0.3 oz-in., depending on size, and balance is maintained at all times. Units are available with 0.0779, 0.0935, 0.1248, 0.1873, or 0.2498-in. diam shafts with over-all lengths to 6 in. Instru-Lec Corp., 520 Homestead Ave., Mt. Vernon, N. Y.

Worm-Gear Lubricants

have high viscosity index

Conedroil A and Conedroil B worm-gear lubricants provide exceptional wettability, extreme pressure characteristics, and a high viscosity index. Conedroil A provides lubrication exceeding AGMA No. 8 and 8A requirements; Conedroil B provides lubrication exceeding AGMA No. 7 requirements. Shear-Speed Chemical Products, Div., Michigan Tool Co., 7125 E. McNichols Rd., Detroit 12, Mich.

Circle 550 on Page 19

Nylon Clamp

for both temporary and permanent cable assembly

Tab-Loc nylon clamp requires no tools for fast, easy clamping and hanging of bundles or single cables. It is adjustable from $\frac{3}{8}$ to $\frac{3}{4}$ -in. diam bundles. Easily opened for adjustment, removal, or addition of wires, clamp is also reusable. It





On land, under the sea, and in space...

BERYLCO° BREAKS DESIGN BARRIERS

Extraordinary properties and performance characteristics of beryllium metal and its alloys have enabled Berylco to assist designers in practically every industry. Creating new products or re-designing existing products, you'll find, as many others have, that checking into the possibilities of Berylco metals and alloys is a wise move.

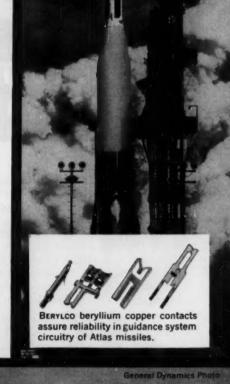
Key parts like bolts for the individually-powered wheels of LeTourneau equipment, components in guidance systems for missiles like the Atlas, and heavy-duty springs in submarines provide higher part performance because of properties found only in beryllium alloys. Good conductivity, formability, high fatigue life, corrosion resistance, and heat resistance are a few of the advantages found in Berylco alloys that offer the solution to many material problems.

Write for latest technical information on how Berylco beryllium alloys can help you break design barriers. Berylco specialists have for over 30 years been helping to turn design possibilities into performance realities.



THE BERYLLIUM CORPORATION

READING. PENNSYLVANIA





BERYLCO beryllium copper springs helped solve a design and performance problem in modern submarines.



Here's information you can use to increase speed and accuracy in high precision control and measuring equipment . . . 4 fact-fifled pages on Holtzer Cabot's line of R-24 Servo Motors.

Contains 3 sets of speed-torque, performance curves: (1) For four different stator stackings with 115V on both windings. (2) For four different stackings with 115V on fixed winding and 200V on control winding. (3) For 0.7" of stator stacking with 115V on fixed winding and 200V, 100, and 50 on control winding. Gives additional data such as starting voltage, stall torque, rotor inertia, acceleration at stall, etc.

The R-24 Line has stator cores of 2.4" diam., available with stacking lengths of 0.5", 0.7", 1.0" and 1.4". Models with or without gear trains. Send for your free copy of Bulletin MO-3.7A. Write: Holtzer-Cabot Motor Division, 125 Amory Street, Boston 19, Massachusetts.



MOTOR DIVISION

National Pneumatic Co., Inc., Boston 19, Mass.

resists vibration to 20 g at 2000 cps and impact shock from 5 g through 120 g. Weckesser Co. Inc., Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill.

Circle 551 on Page 19

Toggle Valve

has handle showing open or closed position

New Instru-Needle valve is a toggle-opening, spring-closing unit for fast off-and-on service, quick connect or disconnect for automatic systems, precision test equipment, and vacuum work. Handle, showing open or closed position, is readily observed from a distance. Brass and stainless-steel bodies are avail-



able, with molded black nylon handles. All are designed for panel mounting, with lock nut furnished. Valve is made in ½ and ¼-in. sizes with internal and external pipe threads, 37-deg flare, and flareless tube connections. It is designed for oil, water, and air services at pressures to 200 psi, and temperatures from -65 to +160 F. Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 35, Ohio.

Encased Photovoltaic Cells

for high output and application

Encased or encapsulated selenium photovoltaic cells available in various sizes and models are designed for high output and application even under adverse atmospheric conditions. Model 857 is of tinned-silver construction in 1½-in. diam with glass front, hermetically or nonhermetically sealed. Model 859 is housed in a 2-in. electrotinned brass case, filled with helium, her-



l'ederal

One of America's largest ball bearing manufacturers



Precisely how precise can you get? Never too much so for Federal's standards. That's why even our master gages have gages to keep them "on the button". In this specially air-conditioned room, we calibrate our master inspection gages on a machine accurate to within 0.000010"! It's one way we insure dimensional accuracy in every Federal ball bearing—radial, angular contact, thrust, self-aligning or shafted. Single or double row. Open or sealed. There are hundreds of types, in all sizes. Send for our catalog today. The Federal Bearings Co., Inc., Poughkeepsie, New York.

Circle 328 on Page 19



COMPLETE POWER PACKAGE
DELIVERED READY-TO-GO

Jeep POWER UNITS

with choice of 4 or 6 cylinder industrial engines

They're complete from radiator to flywheel...ready to go immediately upon arrival, avoiding subassembly costs.

Jeep' Industrial Engines cover the 22 to 92 Max. H.P. range. By concentration on fewer models, more attention has been given to providing a top performing engine. Long-life features such as positive valve rotators, positive crankcase ventilation, stellite or eatonite valves and seats are standard on Jeep' Engines at no extra cast. If you want to deliver value to your customer, look into the value offered by 'Jeep' Power Units and Industrial Engines.

Send for catalog giving details and power curves.

L. P. Gas and Marine Conversion Kits available.



WILLYS MOTORS, INC. INDUSTRIAL ENGINES DEPT. TOLEDO, OHIO

Manufacturers of 4 and 6 Cylinder 'Jeep' Industrial Engines



metically sealed. Both models in hermetically sealed types resist moisture and chemical attack. Plastic-encased cells, Model 9971, are available in rectangular or circular shapes. A 2 5/16-in. Bakelite unit, Model 596, is available for use where atmospheric conditions are favorable and for interchangeability in existing apparatus. Model 9971 circular cells range from 9/32 to 13/4 in. diam. Rectangular cells range from 1/2 to 13/4 in. square. Weston Instruments Div., Daystrom Inc., 614 Frelinghuysen Ave., Newark 12, N. J.

Circle 553 on Page 19

Spiral-Wound Gasket

operates at temperatures from 1250 to 1900 F

Guardian gasket is a spring loaded, thin (to 0.060-in. thick), spiral-wound unit which withstands extreme temperatures and pressures. Gasket uses a ceramic-paper filler which is nonflammable, completely inorganic, and a chemical insulator. Unit operates effectively at temperatures from 1250 to 1900 F. Garlock Inc., Palmyra, N. Y.

Circle 554 on Page 19

Small-Diameter Nut

for ball-bearing screw assemblies

Designed for installations where space is limited, small-diameter nut is available for ball-bearing screw assemblies. On the new ball-bearing screw assembly (lower

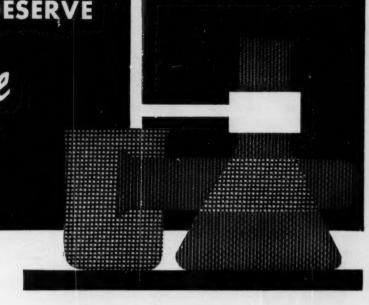


use wire cloth in critical operations?

THEN THEY DESERVE

Cambridge

WIRE CLOTH
QUALITY &
SERVICE



What is Cambridge Quality?

Wire that consistently meets metal or alloy analyses. Trained operators and modern looms to produce cloth from any metal or alloy in any weave. Constant inspection to assure high accuracy in mesh count and mesh size. Craftsmen to make fabrications in any size, shape or quantity to exacting specifications.

This is Cambridge Wire Cloth Quality.

What is Cambridge Service?

Prompt answers to mail or phone inquiries. Experienced Field Engineers experts in their field—who can help you select the wire cloth to do the best job at lowest cost. Prompt deliveries. Large stocks of frequently used cloth for immediate shipment. Follow-up service to see that our product is giving you the results you want.

This is Cambridge Wire Cloth Service.

Your Cambridge Field Engineer can show you how Cambridge quality and service can help you in your operation. Call him at any time. He's listed in the Yellow Pages under "Wire Cloth". Or, write direct for illustrated 120-page catalog.

Refer to our technical data sheet in CHEMICAL ENGINEERING CATALOG, Page 185.





The Cambridge Wire Cloth Co.

Department N . Cambridge 6, Maryland

Manufacturers of Metal-Mesh Conveyor Belts, Flat Wire Conveyor Belts, Wire Cloth, Wire Cloth Fabrications and Gripper ® Metal-Mesh Slings.



BEST POWER FOR STANDARD AND SPECIFIC-PURPOSE APPLICATIONS

Modern as the missile age ... Imperial electric motors are created with a background of more than 70 years of industrial drive experience.

Now, through the use of electronic computers, multiple-design review is made possible in advance of production. Optimum performance is assured while delivery of special-purpose designs is speeded.

For standard NEMA motors and for motors to meet unusual drive requirements, you will do better with Imperial. Write for bulletin covering *The Imperial Line* of integral horsepower motors, generators and motor-generator sets for every application.





DRIP-PROOF A-C MOTOR—Today's Best Buy for Most Applications—Ratings from 1 to 200 Hp.—Designs Include Flange and Face Types, Multi-Speed, etc.

TOTALLY-ENCLOSED, FAN-COOLED A-C MOTOR Provides Dependable Operation Under Abnormal Conditions — Also Available in Explosion-Proof Design—1 to 100 Hp.





SHELL-TYPE SHAFTLESS MOTOR
... Other Special or Specific
Types... Provide Maximum
Power in Minimum Space...
Blend with Basic Design of
Machines.



right), OD of the nut has been reduced 20 per cent, from 0.5 to 0.4 in. Saginaw Steering Gear Div., General Motors Corp., Saginaw, Mich.

Circle 555 on Page 19

Spray-on Vinyl Finishes

for application to phosphated steel, aluminum

Multicolor, spray-on vinyl finishes are available for a wide variety of consumer and industrial products. In a two-step system, decorative finishes in unlimited color and with controllable texture can be applied to either phosphated steel or aluminum by conventional or electrostatic spray techniques. System



permits application of the finish to products after fabrication. Different colors and textures are obtained by changing the vinyl spray material. Coated rejects can be stripped and resprayed. Coatings Div., Metal & Thermit Corp., Rahway, N. J.

Circle 556 on Page 19

Trigger Tube

is equipped with two starters

Type 7709/Z70W subminiature, gas-filled, cold-cathode trigger tube is available for counting, timing, selecting, automation, and read-out applications. Equipped with two starters, tube can also be used in more intricate circuits such as forward-backward counters, gates, and reset applications. Unit is highly sensitive, a starter current of 30 mu amp being sufficient to insure discharge. Physical dimensions are small, making it suitable for use with printed circuits. It is designed for use in dc circuits, and operation is independent of lighting condi-



Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of sonac sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.



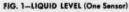




FIG. 2-DRY LEVEL (Two Sensors)

For level control, sonac is accurate to .005" and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which sonac can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because sonac may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

Canadian Representative:

KNOWLES & FOSTER (North America) Ltd.

Circle 332 on Page 19

708 Terminal Bidg., Toronto 1, Ontario, Canada

Sonac is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from -425° F. to $+450^{\circ}$ F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5" x 5" x 5" and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.

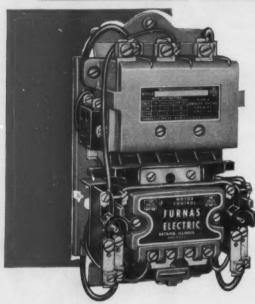
Here's how sonac can be used for sensing and switching applications other than level control.



There are dozens of applications for sonac single and double sensor units. Let it go to work for you now, write:



FORWARD ELES



Furnas Firsts

For many years Furnas Electric has pioneered development of outstanding magnetic control features that are now used extensively throughout the motor control industry. Among "Furnas Firsts" are the outstanding features listed below.

TRULY TRIP-FREE THERMAL OVERLOAD RELAYS—melting alloy type. Non-adjustable trip features assure tamper-proof operation.

ENCAPSULATED DUAL VOLTAGE COILS—greater heat dissipation, and greater mechanical strength. 110-220 or 220-440 volts.

IN-BETWEEN SIZES—provide wider selection of controls to match your motor requirements, effecting savings in cost and space.

AUXILIARY SWITCHLETS—offer easy means for adding auxiliary circuits to the starter at any time,

PRESSURE OPERATED MAGNETIC STARTERS—a single unit offering pilot control for pneumatic and hydraulic systems, eliminating unnecessary wiring and piping.

Write today for full information—1045 McKee Street, Batavia, Illinois



FURNAS

ELECTRIC COMPANY · Batavia, Illinois

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

NEW PARTS AND MATERIALS



tions. Semiconductor & Special Purpose Tube Div., Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Circle 557 on Page 19

Plug and Receptacle

has 3 to 60 circuit connections

Modular plug and receptacle is suitable for applications such as vending and office machines and appliances. It offers multiple-circuit connections from 3 to 60 circuits. Additional polarization is possible by intermixing male and female terminals in plugs and receptacles. Round, pin-type terminals automatically crimped to wires eliminate soldering and permit fast, simple assembly. They snap-lock in po-



sition, and are easily removed with ejector tool. Molex Products Co., 9515 Southview Ave., Brookfield,

Circle 558 on Page 19

Small Blower Wheels

in four diameters from $4\frac{3}{4}$ to $8\frac{1}{2}$ in.

Small blower wheels are designed for use in oil burners, fan-coil units, window air conditioners, space heaters, wall furnaces, kitchen ventilators, and automobile-heating and air-conditioning systems. Diameters are $4\frac{3}{4}$, 6, 7 7/16, and $8\frac{1}{2}$ in., and

TESTED FOR DRAWABILTY

Every sheet, coil or tubing shipment of Quaker State aluminum is now certified in writing. It's your assurance that **your** order has passed our rigid standards of quality control to meet your exacting specifications.

TESTED FOR DRAWABILITY

Although not required by the Aluminum Association Standards, every order to be used in drawing applications undergoes this "cup" test to determine its drawing characteristics. Only afterametal has passed this extra QSM test does it receive the stamp of "Certified Aluminum."



QUAKER STATE METALS COMPANY

Lancaster, Pennsylvania

A DIVISION OF HOWE SOUND COMPANY

Mill Producers of Aluminum Sheet, Coil, Tubing and Extrusions

Circle 334 on Page 19



MILITARY MOTORS are a specialty at Peerless Electric

A military motor has to be fail-proof under the toughest service demands. If not, you take a big loss. The expense of removing a faulty motor for repairs is far greater than it would cost to get a Peerless Military Motor in the first place.

Peerless Electric military motors are available in drip-proof, splash-proof, totally enclosed, spray-tight and water-tight construction from ½ to 30 HP. They meet specifications of ABS, U. S. Coast Guard, MIL-M-17413 (DC), MIL-M-17060A and B, MIL-M-17059 (AC), and AIEE 45. With standard or special mountings and features, they serve at land-based radar installations and aboard vessels throughout the world.

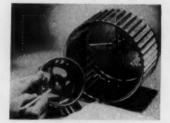
What's your military motor problem? We'll work with your engineers to produce the motor that shrugs off heavy duty and keeps right on delivering . . . that best serves your needs and specifications. Write: Peerless Electric Division, H. K. Porter Company, Inc., W. Market St., Warren, Ohio.

PEERLESS ELECTRIC DIVISION



H. K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.



blade lengths range from 2 to 43/4 in., in 1/4-in. increments. Wheels are aluminum, cold-rolled steel, or Zincgrip; backs are solid, pied out, or coned. Wheels are available in both single and double-inlet types. Blower Div., Lau Blower Co., 2027 Home Ave., Dayton 7, Ohio.

Circle 559 on Page 19

Paper-Base Phenolic Rod

has high strength and good machinability

Insurok T-308R is a paper-base phenolic rod with good physical strength and machinability. It also possesses high density, low moisture absorption, and good electrical properties. Typical end uses include cam-actuated pins, push rods for ignition systems of small-horse-power engines, and inside-threaded caps. Typical axial compressive strength exceeds NEMA XXX standards by 30 per cent. Rod is available in 42-in. lengths with di-



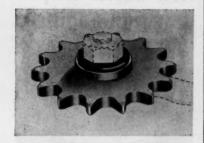
ameters from 0.093 to 0.509 in. inclusive. Natural tan and black colors are available. Richardson Co., Melrose Park, Ill.

Circle 560 on Page 19

Idler Sprockets

for roller-chain drives

Uni-Mount idler sprockets are bearing-equipped and fully assembled to simplify installation on all types of equipment using roller-chain drives. Oil-impregnated bearing is



a press fit in the sprocket bore and a slip fit over the steel journal to eliminate runout. Steel journal is case-hardened to insure long service life. Steel washers are a press fit over the steel journal to provide proper lateral clearance between working parts. Pitch diameters of stock units range from 2.397 to 4.152 in., for chain pitch of 3/8 to 11/2 in. Diamond Chain Co. Inc., 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 561 on Page 19

Bearing Grease

for high and low-temperature use

New ball and roller-bearing grease, filtered to 10 or 45 microns, is for high and low-temperature use. Grease is supplied in 1/2-oz syringes, with needles, as a standard package unit. Primary application is in the regreasing of permanently sealed bearings; many greasing problems existing in miniature and other precision bearings also can be solved readily through use of the product. Bearing Inspection Inc., 3311 E. Gage Ave., Huntington Park, Calif.

Circle 562 on Page 19

Small O-Rings

with flash held to 0.001 in.

Silic-O-Rings are dimensionally stable units available from stock in



June 8, 1961

227







Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSH-INGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION . ZERO SHAKE OR PLAY **ELIMINATE BINDING AND CHATTER** SOLVE SLIDING LUBRICATION PROBLEMS LONG LIFE - LASTING ALIGNMENT

The various types cover a shaft diameter range of 1/8" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.

Dept. E, MANHASSET, NEW YORK

Circle 336 on Page 19

Also Manufacturers of NYLINED Bearings ... Sleeve Bearings of DuPont Nylon, and 60 CASE ... Hardened and Ground Steel Shafting

DANCO

in mind

Have you a problem calling for tough, abrasive-resistant, non-corresive and long-wearing tubing? Then, design with Danco in mind. Whether it's tubing, pipe, rod or strip, you can depend on the uniform quality and performance of Danco. These extrusions in Nylon and other engineering thermoplastics answer the challenge of many design problems where you are seeking a new way... a better way... at lower cost—

design ideas - briefly.

- Economical non-corrosive DANCO TUBING and PIPE for carrying air, cold water, blood, gasoline, and food and milk.
- Goors, bushings, bearings, and other machine parts are easily machined to close tolerances from DANCO ROD and HEAVY WALL TUBING
- Washers, gaskets, and a variety of flat parts can be stamped from DANCO STRIP on high speed stamping equipment.
- NYLON-COATED INDUSTRIAL CABLE in a wide variety of sizes for many applications such as belt lacing, drawing board cables, manual controls, crificial limbs, etc.
- If you are designing, keep Danco in mind. Our experienced trained field engineers can help right from the start.

CUSTOM MOLDED PARTS A pioneer in molding Nylon as well as other engineered thermoplastics, Danco offers complete custom molding service and production.



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THE DANIELSON MANUFACTURING COMPANY

A Subsidiary of Nicholson File Company ARMS AVENUE, DANIELSON, CONNECTICUT

Circle 337 on Page 19

NEW PARTS AND MATERIALS

very small sizes. Flash is held to a maximum of 0.001 in. on all units. Rings can also be custom-molded to meet unusual requirements. A. P. M. Corp., 41 Honeck St., Englewood, N. J.

Circle 563 on Page 19

Rotating Bellows Seal

incorporates pressure-tight bellows

Sealol 605 rotating bellows seal accommodates temperatures from -350 to +800 F. Heart of the seal is a welded, stainless-steel bellows attached to a drive collar at one end and a carbon retainer for the carbon-seal ring at the other end. Sealing of the drive collar to the shaft is accomplished by either a metallic gasket or an



O-ring. Bellows core and two welded fittings rotate as a single unit. Mating ring against which the carbon ring runs is stationary. Seal is pressure balanced; stock sizes accept pressures to 300 psi. Sealol Inc., Providence 5, R. I.

Circle 564 on Page 19

Heat-Stable Laminate

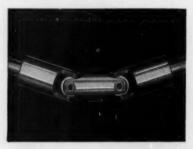
has high dimensional stability

Grade TSA glass fiber-reinforced polyester laminate has properties which meet or exceed NEMA GPO-1 specifications. Material has high dimensional stability under exposure to heat and moisture. It retains 100 per cent of impact strength even after heat-aging at 250 C. Stock can be punched or sheared cold without delamination, cracking, or hole breakout. Grade TSA can be used in a variety of electrical-insulating applications. It is available in thicknesses of 1/16 to 5/8 in. in standard sheet sizes of 36

How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a double Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK — 36" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

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86 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL FOINTS SINCE 1919 x 72 and 24 x 36 in, Heavy sheet stock in standard thicknesses of 3/4 to 2 in, is also available. Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio.

Circle 565 on Page 19

Miniature Gearmotor

is permanent-magnet type for dc operation



Model PM-148 miniature gearmotor has been improved by the use of an additional armature bearing in the new model, and design is more compact in size. Motor is of the permanent-magnet type for do operation. Six models are offered, for input voltages of 6, 12, 24, 28, 32, or 48 v dc. Double gear reduction permits output shaft speeds of 10 to 100 rpm, with a maximum torque of 50 oz-in. Over-all size is 23/4 x 2 in., and weight is 9 oz. Carter Motor Co., 2711 W. George St., Chicago 18, Ill.

Circle 566 on Page 19

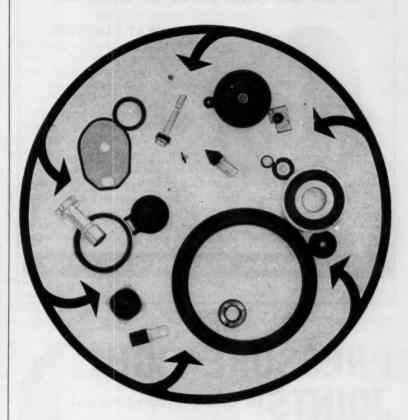
Miniature Filter System

is powered by 1/40-hp continuous-duty motor

Model LAI-1 filter system combines miniature Lucite filter chamber with a miniature epoxy centrifugal pump. Powered by a 140-hp, continuous-duty motor, unit has all components mounted on an 8:: 9-in. linen phenolic panel. Complete with filter tube, vinyl hose, and



PARCO PROBLEM PROBERS ... FAILURE-PROOF BONDING



If your product design includes components where rubber is bonded to metal, how can you be sure that these bonds are failure-proof? There is no known method for testing a bonded joint except by testing to destruction. Failure-proof bonding must be accomplished during component production, not ascertained by subsequent tests. This is where Parco's research, process control, scientifically designed production equipment, exacting production techniques and experienced personnel pay huge dividends in bonded joint quality and dependability. Parco laboratories have thoroughly researched the bonding of rubber to metal and have developed precise and scientific process control's which assure consistent, fail-proof results. Bonding is accomplished with shop equipment specifically designed for this specialized purpose, and by Parco operators with years of experience in bonding. Consult with Parco engineers regarding rubber-to-metal bonded joints which are stronger than the rubber itself.

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ZONE STATE

what some folks won't do to use a

CONWAY CLUTCH

there are two kinds of clutches:



CONWAY CLUTCHES

and those that wish they were Conways.

Evidence the fact that the Conway STATIONAIRE (illustrated) has been copied. Oh well, imitation is the sincerest form of flattery.

Tsk, tsk . . . don't tell our competitors but STATIONAIRE has gone HYDRAULIC! Really, we don't know what the clutch industry would do without us.

WRITE FOR BULLETIN

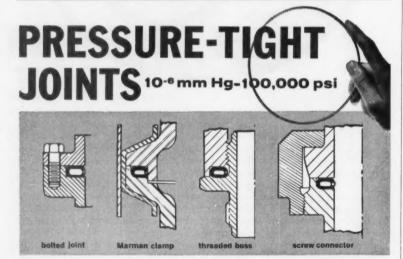
The World's Most Respected Name in Clutches for over a Half-century.

The CONWAY CLUTCH COMPANY

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Cincinnati 25, Ohio

Circle 341 on Page 19



United Self-Energized Metallic O-Rings*...

form positive, permanent, noncorrosive, static seals under pressure extremes from 10-4 mm Hg to 100,000 psi (or the ultimate compression stress of the metal itself) and temperatures from -452° to 3000° F. Available in various metals and coatings (including Teflon** and silver) 1/4" O.D. to any size and configuration. United also makes nonvented and pressure-filled O-rings. United Metallic "O" Rings, manufactured by United Aircraft Products, Inc., Box 1035, Dayton, Ohio.



See United Metallic O-Ring Catalog in Sweet's Product Design File or write for Free Handbook

Patents 2.809.269; 2.837,360 DuPont registered trademark

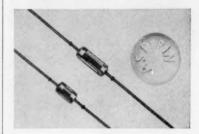
NEW PARTS AND MATERIALS

electric cord, it can be plugged into any two or three-wire, 110-v, ac outlet for immediate operation. Capacity is 180 gph on open pumping. Sethco Mfg. Corp., 2284 Babylon Turnpike, Merrick, L. I., N. Y.

Circle 567 on Page 19

Carbon Film Resistors

microminiature units have tolerances of ±1 per cent

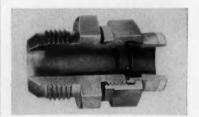


Two microminiature carbon film resistors, PT30 and PT55, are rated 1/10 and 1/8 w respectively. PT30 has a body length of 0.156 in. by 0.090-in. body diam. PT55 meets or exceeds all RN55 MIL specifications and has a body length of 0.281 in. by 0.090-in. body diam. Resistors are hermetically sealed in a borosilicate envelope, locking out moisture and contaminants. Tolerances of both units are ±1 per cent. Pyrofilm Resistor Co. Inc., Box 1521, U. S. Highway 46, Parsippany, N. J.

Rigid Tube Coupling

for all liquids and gases to 700 F

Dynatube rigid tube coupling maintains seal under conditions of vibration, shock, pressure, overloads, pulsing action, or temperature variations. Seal is maintained over extremely wide minimum and maximum tightening torques. Fitting provides absolute dynamic sealing for all liquids and gases to 700 F, and to 1000 F for



How ASARCON Bronze cut to length saves you money

Each time your machinist is left with a costly scrap end from a cast bronze bar, the dollar economy of cut-to-length, continuous-cast Asarcon Bronze is re-emphasized.

When you use 13" cast bars, you have a remnant problem. For example, a 1" remnant from such a bar is over 7.6% loss, a 11/2" piece is over 11.5% loss, a 2" scrap is over 15.3% loss. And the cost of the finished parts must include the purchase price of these remnants.

However, you can buy continuous-cast Asarcon Bronze from stock in lengths up to 105" and cut off short pieces as required, or you can buy cut-to-length pieces to meet each job's specifications. You can eliminate both inventory costs and waste of expensive metal.

In addition to savings on end scrap, Asarcon Bronze bars provide these minimum clean-up allowances: 1/32" on diameters up to 4"; 1/16" on diameters from 4" to 5"; 3/32" on diameters from 5" to 9".

Other important advantages of Asarcon cut-to-length bronze:

- · Available from stock in 263 sizes, solids and tubes, from 1/2" to 9" in diameter.
- Superior metallurgical characteristics no blow-holes, pits, shrinks, hard or soft spots.
- · Better physical properties due to higher tensile, yield and impact strengths; greater resistance to metal fatigue.

For further information, call or write your Asarcon distributor or write: Continuous-Cast Dept., American Smelting and Refining Company, Perth Amboy, N. J., or Whiting, Ind.





tubing to exact length specified by customer.

Cutting stock length of 9" O.D. Asarcon Bronze

Circle 343 on Page 19



For those TOUGH RUBBER PARTS PROBLEMS



Colonial RUBBER COMPANY









From our large number of standard rubber and silicone rubber compounds we can usually furnish a material with just the right combination of properties for your tough rubber parts applications. In unusual cases, our long-experienced industrial rubber engineers and extensive laboratory facilities can give you fast, economical development of the special compound required to meet your specifications.

Whether you are designing new products, or improving existing ones, contact us for details on how you can fabricate more efficiently and at less cost, using rubber parts compounded and molded by Colonial Rubber Company. Call on us for dependable service on:

- ★ RUBBER AND SILICONE RUBBER COMPOUNDING
- ★ FAST, ACCURATE MOLDING PRODUCTION
- * DELIVERIES ON SCHEDULE

1538A

COLONIAL RUBBER CO.

certain applications. It also remains leakproof under cryogenic conditions. Fitting is available in sizes from -3 through -24. Resistoflex Corp., Roseland, N. J.

Circle 569 on Page 19

Miniature Servo Valve

is compatible with all known hydraulic fluids

Mini - Valve 0-2 gpm, electrohydraulic servo valve weighs 2 oz, is $2\frac{1}{8}$ in. long by 1 1/16 in. diam, and is compatible with all known hydraulic fluids. In-line force-feedback system, pressure-balanced construction, and single-nozzle design assure high reliability and proportional



flow vs input signal at low cost. Particles of 200 micron magnitude pass through the large orifice, providing smooth, accurate servo control. Plug-in mounting feature simplifies and speeds up installation or removal of the valve. Instrumentation & Control Systems Dept., Sanders Associates Inc., 95 Canal St., Nashua, N. H.

Circle 570 on Page 19

Electric Vibratory Motors

in three standard units

Electric vibratory motors are now available as standard power sources for a variety of vibratory-power applications such as packaging and assembling machinery, mixers and separators, agricultural and food machinery, and woodworking machinery. Three standard models are available. The largest, Model VM-30, is rated at 4 amp full-load input, at 115 v, 60 cycles. It delivers 14,400 strokes per min through 1/4 in. lineal distances. Motor consists of two separate coils on opposite sides of a Z-shaped stator. Armature, a T-shape, is held in place by a multiple torsion-bar pivot bear-



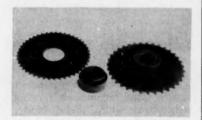
ing. Motion is imparted to a device by attaching the device to four tapped mounting holes on a diecast armature plate. Syncro Corp., Oxford, Mich.

Circle 571 on Page 19

Sprockets and Hubs

for high and low-speed operation

Type A and B die-cut sprockets are available in various sizes. Teeth number from 11 to 36 in larger size and 12 to 112 in smaller size sprockets. Plate sprockets can be converted to hub sprockets with a multiple-spline assembly construction. Concentricity is assured, and sprockets are adapted to both high and low-speed operations. Sprockets are chamfered on both sides, assuring troublefree operations for



roller-chain applications. Dayton Rogers Mfg. Co., 2824 13th Ave. South, Minneapolis 7, Minn.

Circle 572 on Page 19

Insulated Sleeving

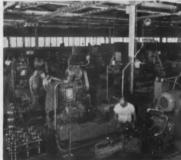
is available on cards with adhesive-backed tapes

Idensulation is insulated tubing with designation or identification codes which have been thermobranded for high clarity. Marked tubing is cut to length and secured to perforated assembly work cards with adhesive-backed tapes. Coded tubing is arranged in numerical, alphabetical, or subassembly order.











...high productivity

AT FAIRFIELD

benefits users of gears

Simple arithmetic explains why, TODAY, many of America's leading machine makers no longer undertake to solve the problems involved in production of gears, differentials, and specially designed gear parts. For them, FAIRFIELD IS THE ANSWER!

Every facility is available at Fairfield-latest, cost-cutting, ultramodern metalworking and heat treating equipment, kept busy by volume production, plus expert engineering counsel. This makes for ECONOMY and EFFICIENCY that can BENEFIT YOU.

Check with Fairfield NOW on your gear production schedules. As one of the nation's largest independent producers, Fairfield can usually give you quickest service available and handle any production requirement. Become a Fairfield customer; it pays! CALL OR WRITE.

FAIRFIELD MANUFACTURING CO., INC.





Material is produced in a wide range of standard insulating materials in a variety of colors. Manger Electric Inc., North State Street, Stamford, Conn.

Circle 573 on Page 19

Neoprene Adhesive

bonds similar and dissimilar materials

Magic Contact Cement joins wood, Masonite, metals, rubber, paper, glass fiber, leather, and most plastics. Application consists of coating the two facing surfaces, allowing a 5 to 15min period for air drying, and firmly pressing the materials to-gether. No clamps are needed. Resulting bend, which is firm but flexible, resists heat, water, and oil. Magic Iron Cement Co. Inc., 14205 Caine Ave., Cleveland 28, Ohio.

Circle 574 on Page 19

Subfractional-Hp Blowers

now have unitized housing

Type D subfractional - horsepower blowers have a unitized housing construction which makes blower simple and strong. Air delivery is 60 cfm for the single unit at 3200 rpm, and 120 cfm for the double unit at 3100 rpm. Housing is coldrolled steel, with baked-enamel finish. Blowers are powered by twopole, shaded-pole induction motor, 115 v ac, 60 cycles. Applications



include vending machines, refrigeration and air-conditioning units, cooling of electronic equipment, and induction heating. Heinze Electric Co., 685 Lawrence St., Lowell, Mass.

Pushbutton Switch Lights

are keyboard-type units

Solenoid hold-down keyboard switch lights are available in various circuit and contact arrangements from SPST to 6PST and SPDT to 8PDT, each with independent lamp circuits. When switch is actuated, coil is energized and holds the pushbutton down in the "in" position. Pushbutton remains in until the coil is remotely de-energized, re-



leasing the pushbutton to the "out" position. When coil is not energized, switching action is momentary. Switches are rated at 28 v dc, 50 mils to 2 amp resistive with silver contacts, and ½ to 50 mils with gold contacts. Holding force is 1½ lb. Pendar Inc., 14744 Arminta St., Van Nuys, Calif.

Circle 576 on Page 19

Magnetic Clutch

features three operating modes

Triplex-type magnetic clutch, Model MC-100, combines two clutches built into one housing. Three shafts extend from the housing ends. At the front end, a 0.125-in. diam shaft passes through the clutch within a 0.250-in. diam shaft. Other end has a 0.250-in. diam shaft. Applying current to one coil or the other permits coupling the 0.250-in. diam shafts individually or simultaneously to the smaller shaft. Available in sizes 5 to 18, the size 11 unit measures 4.689 x 1.062 in. and weighs $8\frac{1}{2}$ oz. Clutch offers



Want better sealing? Then check these 4 PRECISION "O" RING COMPOUNDS!

The next step towards perfect sealing in your product may start with one of these 4 Precision "O" Ring Compounds. Use-proved, they are giving reliable service in hundreds of products.

17507 Industrial Quality Viton, sealing to 550°F in air and oils. Long life service under acids, alkalies, aromatic and chlorinated solvents.

11307 Industrial Silicone for service range from -75° to 450°F in lubricating, hydraulic and pneumatic systems.

1197 Compound for service in fuel oil, gasoline, fuel gas, anhydrous ammonia and lubricating oils. -45° to 250°F.

12137 Polyacrylate service range from — 40° to 350°F in severe service with hypoid gear, and transmission lubricants, both "O" Ring and Lip Seals.

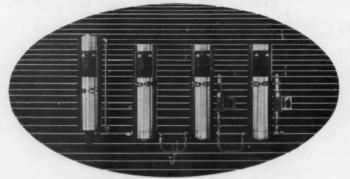
Put maximum reliability in your product by coming to Precision for the **right** "O" ring, made **right**, from the **right** compound.

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ROBBINS DEHYDRATION EQUIPMENT



CARTRIDGE TYPE DEHYDRATION & PURIFICATION EQUIPMENT

PRECISION MADE FOR PERFORMANCE!

TYPE SAFETY FACTOR OF 4 TO 1 ... OIL VAPOR REMOVED AS LOW AS 0.3 PPM/W TOTAL HYDROCARBONS

Robbins disposable desiccant cartridge type drier and purifier equipment is carefully engineered for maximum effectiveness. Chambers are leakproof and cartridges are by-pass proof. Moisture and contaminants in the gas stream are retained in the cartridges, and do not contact the chambers. No tools are needed to change cartridges. Can also be supplied as complete systems, from single to four-chamber, for six maximum pressure ranges and in two maximum flow capacities for each pressure. Porous stone mechanical filters rated at 10 microns are available, as well as fiberglass filterpack cartridges rated at .3 microns.

DESIGNED TO SAVE YOU MONEY!

REFRIGERATION SYSTEMS

Oil Vapor Removed to Less than 1 ppm/w. Foreign Particles Removed to 10 microns Dewpoints to —120°F.

Continuous or Intermittent Operation Automatically Controlled Need No Defrosting

Robbins' refrigeration type gas drier and purification units are individually engineered to meet your needs for the removal of moisture and oil from air, nitrogen, hydrogen, helium, and

other gases. Use of refrigeration increases life of desiccant cartridges 8 times with substantial operating cost savings.

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REFRIGERATION TYPE
DEHYDRATION SYSTEMS
INDIVIDUALLY ENGINEERED



gases N

3817 S. Santa Fe Ave. Los Angeles 58, California LUdiow 9-5221

NEW PARTS AND MATERIALS



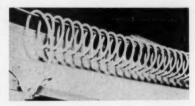
26-70 oz-in. output torque at 24-28 v dc; power consumption is 3 w per coil. Backlash, engaged, is approximately 5 min maximum. Elm Instrument Corp., 30 Chasner St., Hempstead, L. I., N. Y.

Circle 577 on Page 19

Air Hose

is helically coiled to retract when stored

Self-Storing, heavy-duty air hose, helically coiled like a spring, extends to needed working length. After use, it retracts into a small storage space about 1/30th of its maximum working length. Hose is impervious to oils and does not absorb oil. Minimum working pressure with 4 to 1 safety factor is 250 psi at 75 F. Barbed-shank and swivel-barbed shank types are available. IDs range from 3/16 to 3/8 in.



in lengths through 100 ft. Synflex Products Div., Samuel Moore & Co., Mantua, Ohio,

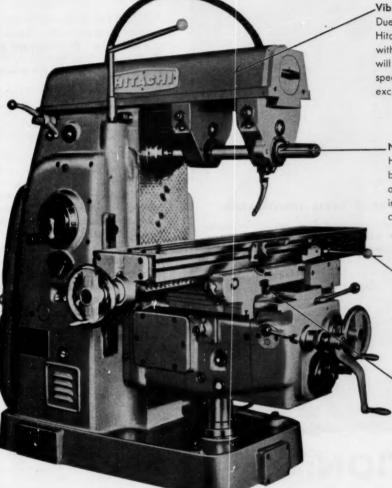
Circle 578 on Page 19

Rigid Polyurethane Foam

has closely controlled dielectric properties

Rigid polyurethane foam produced with ferrous or nonferrous mixture has closely controllable and predetermined dielectric properties. Plastic has a dielectric constant ranging from 1.2 to 3.0 and density can be varied from 2 to 25 lb per cu ft. Components of this material have high strength-to-weight ratio, are lightweight and simple to in-

HITACHI NO. 2 ML MILLING MACHINES



Vibration Damping Device

Due to a vibration damping device of Hitachi's exclusive design contained within the over-arm, minimum vibration will be set up even during higher speeds and feeds operation, so that an excellent finished surface is obtained.

New-Type Arbor Support Bearing Hitachi's unique super precision-type bearing, a combination of plain metal and needle bearing, is incorporated into the machine to enable high speed cutting with high precision results.

Mono-Lever Control System

Hitachi's unique Mono-lever Control System makes the operation simple and easy. Table-feeding too can be performed with ease.

Backlash Eliminator of Lead Screw

As the use of two independent nuts eliminates backlash on the table feed screw, smooth down-cutting can be effected.

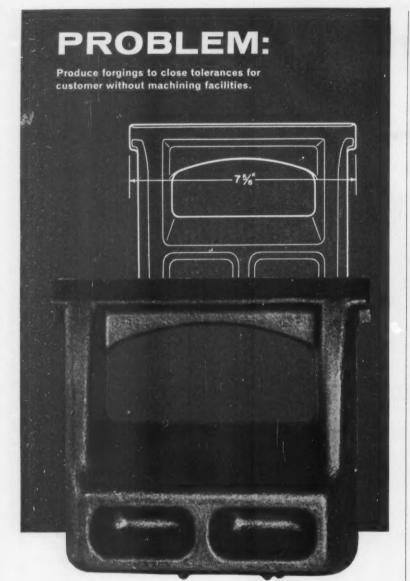
No. 2 ML Plain Milling Machine

SPECIFICATIONS :

- 53 1/8"×10 1/16" Table
- 28" Longitudinal Traverse
- 16 Table Feeds 1/16" 78 3/4"/min.
 - 16 Spindle Speeds 25 1,500 r.p.m.
 - 7.5 h.p. Main Motor



Cable Address: "HITACHY" TOKYO



SOLUTION:

AmForge engineers designed forgings of such tolerances that no further machining was required. Many thousands of these parts have been produced over the years with no tolerance problems for the customer. In checking early installations, forged parts were found to be as good as when first placed in service.

If you have a similar problem part, consult AmForge. Write for our new brochure and the name of your nearby AmForge sales engineer.

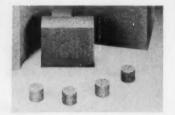
Remember: your problems . . . our challenge!



a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois: Two plants in Chicago, one in Azusa, California

WHEN IT'S A VITAL PART, DESIGN IT TO BE





stall, and are unaffected by normal ambient temperatures, humidity, and salt water. PolyStructures Inc., 41 Montvale Ave., Stoneham, Mass.

Circle 579 on Page 19

Protective Caps

for three-point bayonet connectors

Series 9200/9300 protective caps fit connectors employing the three-point bayonet-locking system used in military, aircraft, and other high-reliability applications. They fit connectors manufactured according to MIL-C-26482 and SCL6019 accurately and easily, providing maximum protection from dust, dirt, and moisture. Available as stock items in eight standard shell sizes from 8 to 22, caps can be ordered with cadmium, nickel, or anodized finish; with silicone or Neoprene rubber gasket; and with or without chain



and washer. NuLine Industries Inc., 1015 S. 6th St., Minneapolis 4, Minn.

Circle 580 on Page 19

Aluminum Foil Coatings

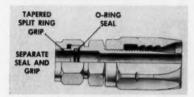
can be bent, cut, flexed, creased, formed

Thermally set Stromiset coatings for aluminum foil are transparent so that the reflection of the surface of the foil beneath produces an interesting effect. Coatings are available in many colors, are highly resistant to the elements, sun, and to alcohol staining. Neither water nor moderate exposure to temperature variations affect the surface. Coatings can be bent, cut, flexed, creased, or formed, and are available in a variety of sizes from large sheets to small specks. Foil Div., Revere Copper & Brass Inc., 230 Park Ave., New York 17, N. Y.

Circle 581 on Page 19

Hose Fitting

requires no adapter



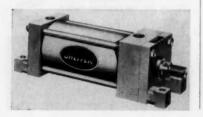
Tube-end hose fitting permits the joining of tube directly to one end of a hose assembly without the use of an adapter. Tube-end incorporates O-ring seal fitting with separate grip and seal which eliminates the need for a female swivel or threading, flaring, or soldering of tubes or pipes. Fitting gives the tube added support and is not affected by vibration. Fitting is available for either double or single wirebraid hose. Full line ranges in hose size from 3/16 to 1½ in. ID with tube OD sizes from ½ to 1½ in. Lenz Co., 3301 Klepinger Rd., Dayton 1, Ohio,

Circle 582 on Page 19

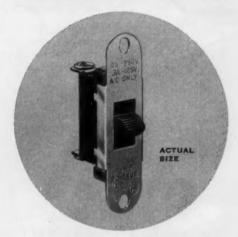
Hydraulic Cylinders

operate to 2000 psi pressure

Medium pressure, Series MH hydraulic cylinders have 1½ to 8-in. bores with 20 mountings. Operating at pressures to 2000 psi, cylinders meet or exceed JIC standards. They feature tie-rod construction for maximum strength and shock loading; long-wearing, easily maintained rod cartridges, removed for



NEW SLIDE SWITCH



PLANNED PERFECTION RUGGED • COMPACT DEPENDABLE

Circle F announces a new, high reliability slide switch. A product of advanced engineering techniques, this new switch features silver alloy contacts and silver plated rockers, with the entire mechanism enclosed in a dust free, Hi-Impact thermosetting plastic case

Slow make — Slow break precision operation Specially designed non-welding contacts

This built-in ruggedness provides the long-lasting dependable service so typical of Circle F products

The new Switch — SPST — is available with screw terminals or with lugs designed for both soldering and push-on tabs $\ \,$

It offers 2 hole mounting • 10 amp 250V A-C - 15 amp 125V A-C

3 amp 250V A-C — 6 amp 125V A-C

Special ratings on request



CIRCLE F MFG. CO.



Only 25% of line pressure required for pilot to open valve. Compact and light in weight. 1/4" and 1/4" N.P.T.F., 3000 p.s.f.



Simple, positive, low-cost way to prevent cylinder creep due to leakage of spool valve. 1/4" to 3/4" N.P.T.F., 3000 p.s.i.



COUNTERBALANCE VALVES

Smooth, positive control of negative loads. Cylinder speed proportioned to pump output. and 1" N.P.T.F., 3000 p.s.i

Simplify hydraulic system design while you get improved performance. Why settle for halfway measures when you can specify a Waterman valve designed for these and other special purposes?

Send today for



725 Custer Ave., Evanston, III.

Circle 352 on Page 19

servicing or replacement with a wrench; and two different types of piston packing for various applications. Dry-seal pipe ports are standard. Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio.

Circle 583 on Page 19

Right-Angle Gearmotors

are 1/8 through 1/3-hp units

Feature of new right-angle gearmotors is a reversible output shaft. Shaft can be transferred to the right or left-hand side of the gear unit



in the field. New 1/4-hp motors weigh 26 lb, 20 lb lighter than the present units. Cast-iron gear case has an integrally cast end shield for mounting footless Duty Master ac motor. Units are available in 1/8, 1/6, 1/4, and 1/3-hp ratings in dripproof, totally enclosed, and fancooled enclosures. Thirteen reduction ratios are offered as standard, Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 584 on Page 19

Precision Potentiometer

in bushing, servo, or tapped hole mounting types

Series 59M14-10 potentiometer has 1/8 in. diam and is available in bushing, servo, or tapped-hole mounting types. Unit offers resistance values from 1000 to 100,000 ohms in linear functions. Standard resistance tolerance is ±5 per cent, with ±1 per cent available on special order. Independent linearity is ±0.25 per cent standard. Unit is available with



Fine Seamless TUBING in

When product design requires small (down to 0.005" O.D.) seamless tubing drawn in copper alloys to extremely close tolerances, your best source of supply is UNIFORM TUBES. With skill and craftsmanship, this specialty mill precision draws tubing to your specifications. Also UNIFORM is uniquely equipped to fabricate dimensionally accurate tubular parts.

ALLOYS - Beryllium-Copper, OFHC, 85/15 Red Brass, 90/10 Commercial Bronze, 70/30 Brass, 67/33 Yellow Brass, Grade "A" Phosphor Bronze, 18% Nickel Silver, 30% Cupro Nickel, and Phosphor Copper.



SIZES-O.D.'s from 0.005" to 0.625". Wall thicknesses from 0.001" to 0.035".

TOLERANCES - ±0.002" to ±0.00025" on smaller sizes if required. Tube lengths are cut as close as ±0.003" with ends concentric and free of

DELIVERY-Normally within two weeks, but if needed "yesterday," orders receive immediate, fast action.

Fine seamless tubing and fabricated parts are also available in the precious metals, aluminum, nickel, stainless steel, steel and glass-sealing alloys. Write for particulars today.



a center tap or multiple taps. Dielectric strength is 1000 v rms for 1 min at atmospheric pressure. Clarostat Mfg. Co. Inc., Dover, N. H.

Circle 585 on Page 19

Panel Meters, Indicators

in 1 and 11/2-in. sizes



Line of internally illuminated miniature panel meters and side indicators includes 1-in, barrel diam meters and 11/2-in. units. Two internally illuminated, side-indicator panel meters are also available. Internal illumination, provided by a built-in light source behind the translucent scale, gives good readability, especially where ambient-light level is low. Illumination is for 28 v lines as standard, with 6 or 14 v optional. International Instruments Inc., 88 Marsh Hill Rd., Orange, Conn.

Circle 586 on Page 19

Miniature Solenoid

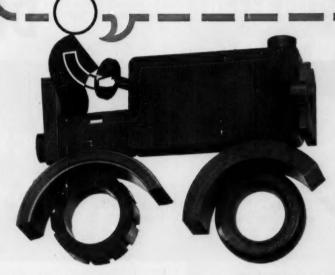
for applications as low as $-420 \, \text{F}$

Miniaturized solenoid has a 1 in. diam and is 13/4 in. long. Weighing 41/2 oz, it delivers 103/4 lb of



force at 0.020-in. stroke at 24 v dc. Type 17-4H steel construction is suited for cryogenic applications as low as -420 F, and also handles applications with coil temperatures to +500 F. Highly reactive missile fuels, oxidizers, and other corrosive media can enter the solenoid cavity

If you're headed for a product requiring magnets



The road leading to a new product may be filled with detours where conventional magnets are concerned. That's where Stackpole Ceramagnet permanent magnets warrant prompt and serious consideration. By providing important characteristics, to extents unobtainable in metallic units, they pave the way to many new and unusual design and engineering approaches.

Ceramagnet's high coercive force permits use without keepers or pole pieces, with many poles on a single flat face, and under other conditions which would quickly demagnetize ordinary units. Moreover, Ceramagnet is chemically inert, electrically nonconductive. Molded from ceramic powders, Ceramagnet permanent magnets can readily be produced economically to practically any size or shape.

For ideas and technical data, write for Ceramagnet Bulletin, Stackpole Carbon Company, St. Marys, Pa.



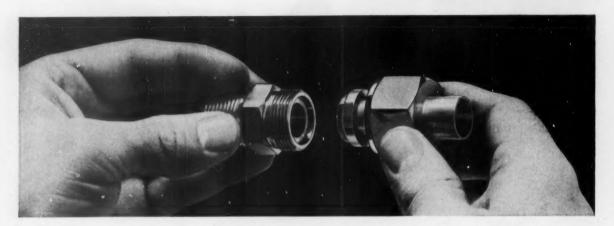
- GRAPHITE BEARINGS & SEAL RINGS . ELECTRICAL CONTACTS . ROCKET NOZZLES . VOLTAGE REGULATOR DISCS . PUMP VANES . CHEMICAL ANODES . CERAMIC MAGNETS . WELDING &
- BRAZING TIPS . FERRITE CORES . FIXED & VARIABLE COMPOSITION RESISTORS . SNAP SWITCHES . AND MANY OTHER CARBON, GRAPHITE AND ELECTRONIC PRODUCTS

PROBLEM:

absolute reliability of a weldless tube fitting under super pressures, high temperatures, high-frequency vibration or shock

SOLUTION:

BRAZE-SEAL



THIS <u>BUTT-JOINT</u>, <u>MAKE-AND-BREAK</u> FITTING WITHSTANDS WORKING PRESSURES UP TO 19,000 P.S.I.*

On many installations where you think only a more costly welded tube fitting can do the job, this Imperial butt-joint BRAZE-SEAL fitting now takes over. It's a compact, economical, simple-to-install fitting withstanding super working pressures (see table). It won't yield to high-frequency vibration or shock. With special brazing alloy rings, this fitting withstands temperatures up to 1500° F.

Because Braze-Seal fittings are not welded, you retain the convenience of a make-and-break joint. For more details, call your near-by Imperial-Eastman distributor—or write for Bulletin 3120.

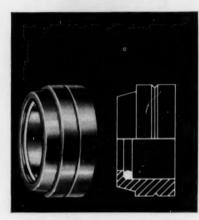
Tube O.D.	P.S.I.—316 Stainless	P.S.I.—Carbon Steel
1/4"	77,000	60,000
3%"	64,000	48,000
1/2"	62,400	46,800
9/16"	61,600	_
5/8"	61,600	46,200
3/4"	60,000	45,000
7/8"	56,000	42,000
1"	52,000	39,000
11/4"	48,000	36,000
11/2"	44,000	33,000

*Recommended working pressures allow for 4-to-1 safety factor on sizes up to 3/4" O.D.; 6-to-1 on sizes 3/4" to 11/2" O.D.



Imperial-Eastman Corporation (Canada) Ltd., Barrie, Ontario • Imperial-Eastman, S.A., Apartado Postal 26544, Mexico 13, D.F.

FITTINGS



secret of superiority silver alloy brazing ring

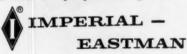
Inside the Braze-Seal fitting sleeve is a brazing ring of silver alloy. When the sleeve is slipped over the tube end and heated, the alloy forms a tough, lasting bond between the tube and sleeve. After brazing, the fitting is easily assembled—no special machining necessary, no special tubing required, no flaring, no danger of "over-torquing" the fitting because you can see when it's tight.

Braze-Seal fittings offer other Hi-Seal fitting advantages: make-and-break convenience, close bends made possible, and economy of installation.



6-FLAME TORCH SPEECS BRAZING

This Braze-Seal acetylene torch simplifies the making of brazed joints. Sixflame jet on circular tip heats sleeve evenly—quickly brazes the silver alloy to form a super-pressure-tight seal.



without fear of contamination or corrosion, and exterior of the unit withstands fumes and accidental spillage without damage. Electroid Corp., 95 Progress St., Union, N. J. Circle 587 on Page 19

Brushless Frequency Converter

has 2.5 kva output

Brushless frequency converter for single-phase drive supplies three-

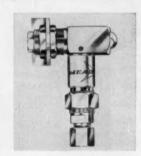


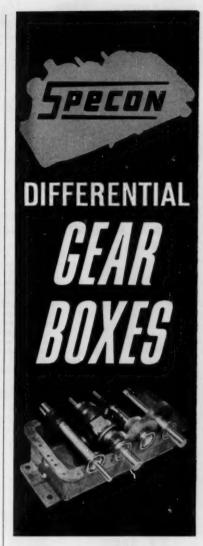
phase, 400-cycle power from a 60-cycle source. Utilizing a low-slip, single-phase motor built into a cast-aluminum shell, integral with a NoBrush 400-cycle alternator, low intrinsic regulation characteristic of the unit eliminates the need for an external regulator. Output is three phase, four wire, 120/208 v, 2.5 kva. Georator Corp., Manassas, Va.

Limit Valve

has adjustable bleed duration

No. 408 interlock limit valve actuates differential-pressure master valves of the pilot-bleed type. It bleeds only enough air to shift master valve before closing itself automatically. Bleed duration can be varied to meet circuit requirements that change with distance from master valve, master-valve capacity, and speed of actuation. Flow directuations.





Differential assemblies precision crafted by Specon for drives and transmissions are available as gear boxes alone. These task-proven assemblies offer the built-in advantages of Specon units: extreme accuracy, low maintenance, rugged, space saving construction. Seven basic models are rated from 1 hp. to 75 hp. Specials and units for higher power can be supplied. The Specon units are particularly well suited for such applications as phase and register control, speed control, torque dividing, overriding, cycling and balancing operations.

For full information on Specon gear boxes, drives and transmissions, write to:

STRATOS'

A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION Industrial Products Branch Route 109, West Babylon, L. I., New York MULTIPLE-USE

CONSOLE CABINET

OIL-TIGHT and DUST-TIGHT

Made of 14 gauge steel with welded seams. Height 50° width 24°, depth 23°. Writing desk optional.



WITH WIDE APPLICATIONS IN BOTH ELECTRICAL AND ELECTRONIC FIELDS



This Hoffman Model 14 heavy-duty oil-tight console enclosure is designed as an operator control station with maximum flexibility to meet variable needs. The sloping front panel is ideal for mounting meters, switches and pushbuttons.

Flush key-locking gasketed doors, front and rear, provide access to lower sub-panels which can be either stationary or swing-out. Note provision for pull-out electronic chassis and rack panels if desired, or combination stationary panel with pull-out chassis. This is the most versatile, heavy duty, all-welded oil tight and dust tight cabinet available today! Write immediately for Bulletin 139.

Hoffman Engineering Corporation
Dept. MD-171
Anoka, Minnesota

Circle 357 on Page 19

HOBBS GIVE THE REAL FACTS OF INDUSTRIAL TOOL USE AND MAINTENANCE

Hobbs Industrial Hour Meters provide continuous supervision of the running time of industrial machines... eliminating errors and deficiencies for maximum production. These elapsed time indicators tell when servicing is due... indicate the costs of running hour for both the machine and occupied space.

Hobbs Industrial Hour Meters make it easy to determine the life and repair costs per running hour of industrial machines . . . the actual running time of leased equipment and equipment to be sold. They set up a sound basis for service contracts. For complete information . . .



John W. Hobbs Corporation

A DIVISION OF STEWART-WARNER CORPORATION
2002 YALE BLVD. SPRINGFIELD, ILLINOIS



NEW PARTS AND MATERIALS

tion can be changed by another limit valve even while actuator remains depressed. Mead Specialties Co., 4114 N. Knox Ave., Chicago 41, Ill.

Circle 589 on Page 19

Air-Cooled Engine

has high piston displacement



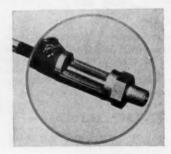
Red Seal air-cooled, 5-hp, AU-12 engine is designed for use in scooters, concession carts, and similar applications where maximum ruggedness is needed. It is a heavy-duty, four-stroke cycle type. Double-capacity connecting rod of forged aluminum has replaceable Babbitt insert bearing. Silchrome insert in the exhaust-valve seat minimizes burning and wear. Air-Cooled Industrial Div., Continental Motors Corp., 12800 Kercheval Ave., Detroit 15, Mich.

Circle 590 on Page 19

Hydraulic Hose

withstands minimum pressure of 50,000 psi

Super-Spiral, six-ply, wire-reinforced hydraulic hose is for use in temperatures from -40 to +200 F. It withstands minimum burst pressure of 50,000 psi, Construction consists of an oil-resistant Neoprene inner tube, covered by an open textile-braid reinforcement. Interply fric-



How to choose a metal for sub-zero service

What metal do you use in equipment for sub-zero studies in chemistry and physics... in pressure vessels and auxiliary equipment for storage of ethylene at $-155^{\circ}F$... in tanks and ocean-going barges that must handle liquefied gases at $-258^{\circ}F$... in storing and piping equipment for liquid nitrogen at $-320^{\circ}F$ or liquid helium at $-452^{\circ}F$?

Just any metal won't do: in each case the equipment must be made of a metal that retains its toughness where other metals embrittle in crippling sub-zero temperatures.

Which metal to use...and where?

-21/4% NICKEL STEEL-

For moderately low temperature service, this nickel steel offers a combination of good mechanical properties and superior resistance to brittle fracture at temperatures down to -75°F. 2½% nickel steel may be found at work in refrigeration equipment, cooling apparatus, and machinery and structures in very cold climates.

Design Data

ASTM A-203 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
A	65,000	37,000	16,250
В	70,000	40,000	17,500

Welding Materials: For manual metalarc welding, use low hydrogen coated electrodes of the E8015-16-18 C1 Classification conforming to AWS-ASTM specification A316. These electrodes will deposit a weld metal of essentially base metal composition.

-31/2 % NICKEL STEEL-

Low carbon $3\frac{1}{2}\%$ nickel steel has both high strength and a resistance to brittle fracture which has led to its use as a standard material for pressure vessels operating at temperatures down to $-150^{\circ}F$ —vessels for manufacturing, storing and transporting liquefied hydrocarbons. It is also widely used in aircraft testing units and equipment for oil refinery processes.

Design Data

ASTM A-203 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
D	65,000	37,000	16,250
E	70,000	40,000	17,500

Welding Materials: For manual metalarc welding, low hydrogen type electrodes of AWS-ASTM Classification E8015-16-18 C2 will deposit weld metal containing not over 0.10 carbon and 3% to 3½% nickel.

- 9% NICKEL STEEL-

Low carbon 9% nickel steel provides an excellent combination of strength and notch toughness at temperatures down to -320°F. Specifically developed to meet engineering demands for an economically priced metal for low temperature service, this material is produced in the quenched and tempered or double normalized and tempered conditions. Operation Cryogenics has demonstrated that this material may be used safely even without thermal treatment after welding. At the present time an ASME code case is being prepared to use pressure vessels made of either of these conditions, omitting the post-weld heat treatment. 9% nickel steel is at work in equipment handling such products as liquid methane at -258°F, oxygen at -297°F, and nitrogen at -320°F.

Design Data

ASTM A-353 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
A	90,000	60,000	22,500
В	95,000	65,000	23,750

Welding Materials: Best results are obtained with Inco-Weld* coated electrodes or wire of a high nickel-chromiumiron composition. Inco-Weld "A" electrode is used for manual welding, and Inco-Weld "A" wire is used for inert gas welding with tungsten electrode or inert gas-metal arc welding.

- 304 NICKEL STAINLESS STEEL -

Types 304 and 304L nickel stainless steels are very well-suited for service at extreme sub-zero temperatures down to -452°F, the temperature of liquid helium and the lowest measured service temperature. These nickel stainless steels are widely used in low temperature service because they are easy to fabricate, do not require heat treatment after fabrication, and have high strength with superior ductility and shock resistance at very low temperatures. And because of their corrosion resistance, nickel stainless steels are employed wherever high product purity and ease of cleaning following fabrication are essential - as in the handling of missile propellants. In fact, for optimum corrosion resistance at any temperature in the sub-zero range, nickel stainless steels are the best choice.

Design Data

ASTM A-240 Grade	Tensila Strongth psi, min.	Yield Strength psi, min.	Allewable Tensile Design Stress ASME, psi, max.
304	75,000	30,000	18,750
304L	70,000	25,000	17,500

Welding Materials: For metal-arc welding, use coated austenitic stainless steel electrodes conforming to AWS Classification E308 ELC-ASTM A298. Inert gas-metal arc welding requires ER308L wire conforming to ASTM A371.

Cold Facts on Metal Economy

Interestingly enough, the nickel alloy steels increase significantly in strength as the temperature is lowered into the sub-zero range. For example, 9% nickel steel has a tensile strength at room temperature of 105,000 psi; at -320°F its tensile strength is 165,000 psi.

The high room temperature tensile properties of these nickel alloy steels which manifest themselves in higher code design strengths makes it possible to use thinner, more economical sections with complete safety. As the structure is cooled to its sub-zero operating temperature, the characteristic response of the nickel steels—an increase in strength while still maintaining toughness—further confirms the wise selection of these steels in sound engineering design.

LITERATURE

The publications listed below are especially recommended for guidance in selecting metals for sub-zero service.

Publication Number

Name

A269 . . . Properties of Nickel Steel Plates at

A263 . . . 9% Nickel Steel for Low Temperature Service A278 . . . 3½% Nickel Steel for Low Tempera-

ture Service
A273 . . . 24% Nickel Steel for Low Temperature Service

ture Service
... Operation Cryogenics
A276... Steels for the Containment of Lique

A276... Steels for the Containment of Liquefied Gas Cargoes

A complete listing of Inco publications

and technical bulletins can be obtained by writing for "List A" to:

*Registered trademark.

The INTERNATIONAL NICKEL COMPANY, Inc.

67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER



OIL SEALS

"Garlock KLOZURE Oil Seals have proven consistently satisfactory in sealing motor shafts." W. T. Hedlund Manufacturing Company makes this report after specifying the seals to protect bearings and keep water from the motor of their Whirl-A-Way Food Waste Disposers. Hedlund finds other advantages of KLOZURE Oil Seals, too—less downtime, longer life, easier to install—and adds finally that "... leaky units have become negligible."

Take a tip from Hedlund. Design with Garlock KLOZURE Oil Seals. Where bearings need the best protection . . . on pumps and motors, on power shovels and lift trucks, in steel mills . . . KLOZURE Oil Seals prevent leakage of lubrication, seal out foreign matter. KLOZURE Oil Seals are oil and grease resistant, impervious to mild acids and alkalies, non-abrasive, and will withstand temperatures from -40° Fto $+250^{\circ}$ F.



As a shaft seal for their Whirl-A-Way Disposer Units, W. T. Hedlund Manufacturing Co. selects Garlock KLOZURE Oil Seal Model 92 with rubbercovered metal case and stainless steel garter spring.

Special seals are available for service against harsh corrosives at temperatures to $+500\,^{\circ}\mathrm{F}.$ If you

have a particular sealing problem, get in touch with your local Garlock representative. He can furnish you with complete design and application information. Why not call him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-181. Garlock Inc., Palmyra, N.Y.

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket
Company

Order from the complete line of quality Garlock products—Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.



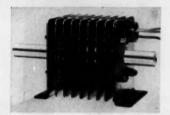
GARLOC

tion layers cover six plies of spirally wrapped, heavy-wire reinforcement. Tough, synthetic-rubber outer cover resists sun, weather, oil, and abrasions. Hose is available from 3/8 to 11/2 in. ID. Anchor Coupling Co. Inc., 342 N. Fourth St., Libertyville, Ill.

Circle 591 on Page 19

Linear Actuator

standard unit has stroke to 6 in.



Polynoid electromechanical linear actuator, designed to meet a wide range of requirements, is available in six models featuring different stroke lengths and output forces for testing, evaluation, and prototype use. Models operate on standard ac voltage and are furnished for foot mounting. Actuators contain only one moving part, and can be used to hold under load at any position or provide reciprocating motion. Stroke is up to 6 in. with standard units. Skinner Precision Industries Inc., New Britain, Conn.

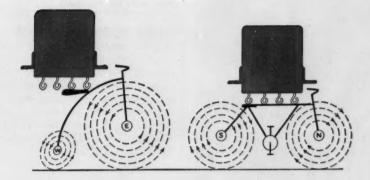
Circle 592 on Page 19

Glass Zener Diodes

28 types have 3.3 to 30-v range

For printed-circuit boards, miniature circuitry, and other applications where miniaturization is necessary, subminiature glass zener diodes with wide voltage range and rated at 250 mw power dissipation are available, High stability and





some relays are quite differential from others

If you want something to happen when a predetermined difference exists between two signals, gather 'round. Almost every* available subminiature dual coil "differentia" relay we know of must have the "trip" signal applied to a specific coil and consequently the "reset" signal to the other coil. The dilemma stems from the lack of symmetry between the two flux paths or magnetic circuits of such a dual coil relay (the total pole gap changes with armature position). In a situation like this it takes more power to move the armature in one direction than the other, and when normal safety margins are added to operating power levels the disproportion becomes extreme. If you've found yourself with a relay that is this choosy about how and whether it transfers its contacts, you know you have anything but "true differential operation".

In typica! and magnanimous fashion, we will now present THE SOLUTION, hoping that in due course it will also sell some of our relays. For true differential operation, without the pitfalls, we commend to your attention our subminiature Series

*Except ours, of course.

. . .

true for the stated 100-milliwatt sensitivity. Safety margins needn't be added just to make the specs hold true in practice. If you've never used two collector circuits of a bistable whats-it to drive a dual coil polarized relay differentially, who knows what joys may await you? Write to Sigma today, telling us your differential troubles.

32 DPDT dual coil magnetic latching

relay. The moment there's 100 milliwatts

more on one coil than the other - regard-

less of how gradually the differential has

taken place - the contacts transfer syn-

chronously and completely. Hang up,

blackout and those other monstrous con-

tact mistakes often brought on by "sliding

current" signals are neatly avoided by the

design and adjustment of the "32". Its

magnetic circuits and flux paths are as

symmetrical as grapefruit halves, the gap

remains constant no matter what the

armature position, and essentially 100%

cancellation occurs between coils. The

30 g to 5000 cycles vibration (operating

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Circle 593 on Page 19

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has extreme input-output latitude

Coaxial-shaft speed reducer, Size 8, with extreme input-output latitude, provides maximum compactness and weight saving. Gear train receives ultrahigh input speed via smaller, inner shaft and returns extremely



reduced output speed via larger, outside shaft. Unit meets applicable portion of MIL-B-5272A. Lifetimelubricated, ABEC-7 ball bearings are furnished throughout, except outside end of input shaft, which is Oilite. Planet Instrument Inc., 616 S. Lafayette St., Fort Wayne, Ind.

Circle 594 on Page 19

Hydraulic Cylinders

in 11/2, 2, and 21/2 in. bore sizes

YDS 10,000-psi double-acting hydraulic cylinders are available with choice of stroke length in bore sizes of 11/2, 2, and 21/2 in. Cylinders are designed primarily as "push" cylinders, but with sufficient "pull" force to return the ram from such work as punching, forming, and broaching where spring return is inadequate. Although not designed for continuous pull duty beyond 3000 psi, units withstand 10,000



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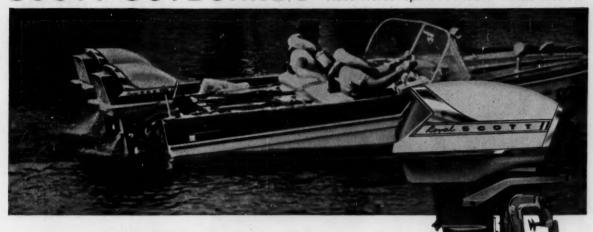
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psi safely on the basis of occasional use. Precision Hydraulics Div., Owatonna Tool Co., 712 Cedar St., Owatonna, Minn.

Circle 595 on Page 19

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plastic bearing material. Has good mechanical strength, chemical resistance and frictional properties. Easily machinable.

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6. FLUOROSINT® TFE COMPOSITION A TFE base material which has excellent mechanical stability up to 500°F. Exhibits superior wear resistance while maintaining the electrical and chemical resistance of unmodified TFE-fluorocarbon.

7. NYLATRON® GS NYLON A molybdenum disulphide-filled nylon formulated with premium bearing properties. The moly-sulphide filler provides a low coefficient of friction and excellent abrasion resistance.

*Hercules Powder Trademark
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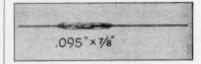
resists oxidation and weathering

Fluoran F-5000 fluoro-elastomer has maximum operating temperatures of 400 F in continuous service to 600 F in intermittent use, and a low-temperature brittle point near -40 F. Material, available in tubing, hose, and press-polished sheets, has a broad range of resistance to corrosive chemicals, fuels, and lubricants. Tensile strength ranges from 2000 to 3000 psi at room temperature, and ultimate elongation varies from 100 to 400 per cent. Parts made of the material afford excellent resistance to oxidation and weathering. Plastics & Synthetics Div., U. S. Stoneware Co., Akron 9, Ohio.

Circle 596 on Page 19

Magnetic Reed Switch

has glass length of 7/8 in.



Model MR-400 magnetic reed switch makes possible the use of miniature relays and cross-points in printedcircuit boards or modules based on a 0.1-in. center. Model features excellent bounce characteristics, fast snap-action, and relatively high contact force. External leads are adaptable to both welding and soldering, and may be bent or cut for printedboard applications. Switch has a glass length of $\frac{7}{8}$ in. and over-all length of $\frac{23}{4}$ in. Gordos Corp., 250 Glenwood Ave., Bloomfield, N. J.

Circle 597 on Page 19



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Catalog G-101.

*Consumer net price, including sliding motor base, Reeves variable pitch pulley and drive belt.

	epower aximum speed)	1/2	3/4	1 or 1½	2	3	5	7½ or 10	15
	able Driven ut Speeds	1670 to 210 rpm	1515 to 200 rpm	1870 to 245 rpm	1545 to 195 rpm	1435 to 210 rpm	1560 to 225 rpm	1560 to 235 rpm	1065 to 375 rpm
	r Pulley Diameter imum speed setting)	51/2"	6"	71/2"	8"	9½"	10"	12"	12"
Moto	r Pulley Size ber	95	96	97	98	99	910	912	912-15

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Standard Gear Series A	½ to 7½	716,310	12,000
Francke Pin Type	% to 10½	567,000	4,000
Nylon Gear Series M	½ to 2	2,200	5,000
All Nylon Series J	% to %	100	10,000
High Speed Series HS	1/2 to 8	1,197,000	70,000
Cutout Coupling Anchor-Waldron	1/2 to 25/8	5,200	3,000
Cutout Pulley Anchor-Waldron	% to 25%	17,500	2,400
Heavy-Duty Gear	4 to 13	2,520,000 5,000,000	St'd 2,000 Forged 4,000
High Misalignment Series X	1 to 6	400,000	6,500

This is merely a sample of the Waldron line, which also includes mill motor, floating shaft, Jordan, shear pin, vertical, spacer, oil collector, marine, brake wheel, and continuous lubrication types. Write for catalog or data sheets on the types you are considering.

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ENGINEERING DEPARTMENT

EQUIPMENT

Weldable Strain Gages

provide stability from cryogenic to 750 F temperature

Weldable strain gages incorporate SR-4 foil gages bonded to 0.005-in. thick stainless-steel shim stock. Two basic types are available: Phenolic-bonded Constantan foil, for temperatures from cryogenic to 500 F; ceramic-bonded Nichrome V foil, for temperatures to 750 F continuous or 1000 F intermittent. Gages are free from local buckling, enhancing the extreme linearity of



strain response in either tension or compression. Both types operate in a strain range of ±0.50 per cent. All gages have a nominal resistance of 120 ohms and can be used with conventional circuitry and instrumentation. Electronics & Instrumentation Div., Baldwin - Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.

Circle 598 on Page 19

Temperature Recorder

for temperatures to 2500 F

New temperature recorder operates on a pyrometer principle, utilizing the output from a thermocouple junction through a temperature compensator to cause deflection of a sensitive galvanometer. Since there is no amplification in the recorder, it is supplied with a 6-ft thermocouple connected to the rear terminals of the recorder directly. Each recorder is a complete system and



needs no additional accessories. Temperature spans are 0 to 500, 0 to 1000, 0 to 1500, 0 to 2000, and 0 to 2500 F. Accuracy is 2 per cent. Rustrak Instrument Co., 130 Silver St., Manchester, N. H.

Circle 599 on Page 19

Drawing Tables, Desks

provide co-ordinated working units

New drawing table and reference desk combinations provide a convenient, complete working unit. Floating-board drafting table has Toe-Touch pedals that give complete control, from a seated position, of every board height from 30 to 45 in. and any angle from 0 to 90 deg. Drawing surface is nonglare, washable, resilient, and self-sealing. Desk has a color-harmonized, plastic top. Large, shallow tool and catalog drawers have nylon bearing suspension and rubber bump-



ers, and tubular legs have floor-leveling devices. Stacor Equipment Co., 285 Emmet St., Newark 5, N. J. Circle 600 on Page 19

Pressure Transducer

has low sensitivity to acceleration

General - purpose, Zero - length/dimensionless, unbonded strain-gage pressure transducer, P707TC, measures absolute and gage pressures

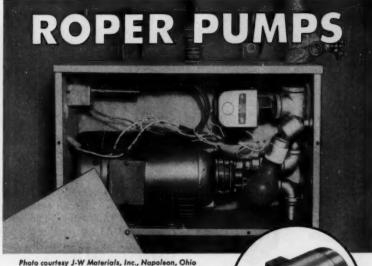


Photo courtesy J-W Materials, Inc., Napoleon, Ohio

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deliver liquid water-reducing admixture for concrete

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Circle 368 on Page 19

ENGINEERING DEPT. EQUIPMENT



from 0-5 through 0-5000 psi. Transducer is small in size, is lightweight, and has low sensitivity to acceleration. Excitation is 5 v for gage model and 7 v for absolute model, dc or ac (rms) through carrier frequencies. Output of gage model is 25 mv, and 35 mv, full-scale open circuit, for the absolute model. Ambient temperature limits are -100 to +275 F. Statham Instruments Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.

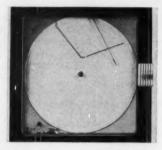
Circle 601 on Page 19

Transistorized Recorder

provides magnetic flowmeter, ac potentiometer

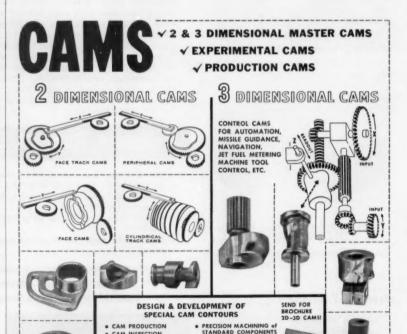
Compact, transistorized recorder

has positive-drive action, built-in voltmeter, and direct-reading range dial. Recorder provides a stable, noisefree magnetic flowmeter ac potentiometer. Entire unit is built on a single removable chassis, with amplifiers, preamplifiers, and a range network mounted on plug-in cards that can be removed and replaced easily. Unit also features an automatic quadrature rejection which requires fewer adjustments while providing a high level of stability, and has a built-in dashpot.



Single-depth case can be direct wall-mounted. Fischer & Porter Co., 862 Jacksonville Rd., Warminster, Pa

Circle 602 on Page 19



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Mechanization of Motion. By Lee Harrisberger; 363 pages, 5¾ by 9 in., cloth-bound; published by John Wiley & Sons Inc., 440 Park Ave. South, New York 16, N. Y.; available from Machine Design, \$8.50 per copy postpaid.

This book combines the fundamentals of kinematics, techniques of "ideation," and techniques of analysis in a step-by-step presentation of logical procedures for synthesizing mechanical systems. The first of three parts discusses the creative approach, mechanization, and motion. The second part treats uniform rotary motion including rotary transmission, equations of rolling motion, and synthesis of gear trains. The last part deals with nonuniform motion including synthesis of cam mechanisms, noncircular gear trains, and linkage systems.

Advances in Cryogenic Engineering, Volume 6. Edited by K. D. Timmerhaus; 662 pages, 6½ by 10 in., clothbound; published by Plenum Press Inc., 227 West 17th St., New York 11, N. Y.; available from Machine Design, \$15.00 per copy postpaid.

Significant developments in cryogenics—the science dealing with phenomena occurring at ultra-low temperatures—are summarized in the Proceedings of the 1960 Cryogenic Engineering Conference. This volume contains 65 papers which discuss progress in the following general areas: space technology, superconductivity, transfer phenomena, physical equilibria, cryogenic equipment, mechanical properties, and heat transfer and thermometry.

1961 SAE Handbook. 914 pages, 8½, by 10¾ in., clothbound; published by Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; available from Machine Design, \$20.00 per copy postpaid.

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on standard specifications, test requirements and procedures, and components and materials for the automotive and related industries. This issue is divided into broad sections on ferrous and nonferrous metals, threads, fasteners, and common parts, electrical equipment and lighting, powerplant components and accessories, passenger cars, trucks, and buses, tractor and earth moving equipment, and marine equipment. New material has been added on central system fluids, nondestructive test methods, lubricant types, test procedure and ratings for hot water heaters, tire selection, automotive transmission diagrams, and exhaust flanges.

Broaching-Tooling and Practice, Bu Horace E. Linsley; 216 pages, 6 by 9 in., clothbound; published by The Industrial Press, 93 Worth St., New York 13, N. Y.; available from Machine Design; \$6.50 per copy postpaid.

Technical and general information covering the field of broaching is presented as a possible guide to reduction of production costs. Various kinds of broaching operations are explained, such as spline broaching, gear broaching, rotary broaching, straddle broaching, broaching, and horizontal surface broaching. The design of broaching tools is covered in detail and a separate chapter is devoted to broaching fixtures.

Resistance Welding Manual, Third Edition, two volumes. Edited by E. J. Del Vecchio; 617 pages, 6 by 9 in., clothbound; published by Resistance Welder Manufacturers' Association, 1900 Arch St., Philadelphia 3, Pa.; available from Machine Design; \$7.00 for both volumes, postpaid.

This revised manual presents a comprehensive source of data on resistance welding, including all advanced techniques. Welding proc-ess and materials are covered in two sections in the first volume, including spot, projection, and seam welding, flash and upset butt welding, and cross-wire welding. Materials include low-carbon steel, high-carbon and low-alloy steel, coated and plated steel, aluminum and aluminum alloys and miscellaneous dissimilar metals. second volume discusses quality



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High Strength Steels for the Missile Industry. Edited by H. T. Sumsion; 276 pages, 81/2 by 11 in., clothbound; published by American Society for Metals, Metals Park, Novelty, Ohio; available from MACHINE DESIGN; \$12.00 per copy post-

Problems in development and application of ultra high strength metals for missiles are presented. The book is comprised of ten papers presented during the Golden Gate Metals Conference in San Francisco on February 4-6, 1960. Contents include materials and fabrication problems in pressure vessels, stress corrosion of aircraft and missile steels, fracture theory in pressure vessels, pressure-vessel reliability, high-strength sheet alloys, fabrication techniques for rocket motors, and shear spinning in fabrication of solid-propellant rocket cases.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Of-fice of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 171101. Properties of Refractory Materials: Collected Data and References. By Wanda G. Bradshaw and Clayton O. Matthews, Lockheed Aircraft Corp.; 107 pages, 10½ by 8 in., paperbound, stapled; \$2.50 per copy. A survey of elevated-temperature characteristics of refractory materials melting above 2500 deg F was made. Data on melting points, ductility, and elevated stability of refractory metals, carbides, nitrides, silicides, sulfides, beryllides, aluminides, and others are presented. Thermal shock resistances, thermal conductivities, thermal expansions and emissivities for these materials are given. Mechanical properties are briefly reviewed and sources of thermodynamic data are included.

PB 171102. Paperlined Magnesium Dry Cells and Batteries. By P. F. Albert, 38 pages, 8 by 10½ in., paperbound, stapled; \$1.00 per

by 10% III., paperbound, stapieu, elice percopy.

This survey obtained initial, high temperature, and delayed performance values on six different sizes of magnesium cells and seven different types of magnesium dry batteries. Cells were assembled using paperlined construction, natural African manganese oxide, and uncoated Kraft separator paper.

and uncoated Kraft separator paper.

TN D-837. Influence of Impurity Elements, Structure, and Prestrain on Tensile Transition Temperature of Chromium, By B. C. Allen, D. J. Maykuth, and R. I. Jaffee, Battelle Memorial Institute; 48 pages, 7% in. by 10½ in., paperbound, \$1.25 per copy. Research was conducted to obtain basic information on the structural and mechanical properties of high-purity chromium, and the resulting influence of impurity elements on the tensile ductile-to-brittle transition behavior and room-temperature ductility. The separate effects of carbon, oxygen, and sulfur additions on the tensile properties of iodide chromium in the wrought and recrystallized conditions were evaluated as a function of temperature and cooling rate.





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Planning New Products, by Philip Marvin, 1953-1958 (102 pp.) \$3
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Special Report on Electric Motors, Staff Report, 1958 (42 pp.) \$1
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of over 15 years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished 60 Case parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of 60 Case parts, with or without special machining. Write for literature and name of your local representative.

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ADVANTAGES of 60 Case

- COST REDUCTION
- GROUND FINISH
- . HARD BEARING SURFACE
- . STRAIGHT PARTS
- . NICK-& DENT-PROOF
- · DELIVERY FROM STOCK
- - . UNIFORM HIGH QUALITY

TYPICAL 60 Case PARTS

GUIDE RODS • SHAFTING • ROLLS • TRAVERSE RAILS
PISTON RODS • ARBORS • LEADER PINS • TIE RODS
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THOMSON INDUSTRIES

Inc.

Dept. C-5, Manhasset, New York

Circle 375 on Page 19

PARTS HARDENED to 60 C...

increase life...reduce cost!

PROXIMITY LIMIT SWITCHES

ALL STATIC—ACCURATELY LIMIT THE MOVEMENT OF MACHINES OR PARTS

Reliable—rugged—all static—corrosion resistant—can't wear out.

Not affected by oil mist, iron filings, sand, dust, dirt or water. Very successful in underwater applications. Tripped by any magnetic material. Has passed Navy shock and vibration tests (MIL-S-901B) and (MIL-STD 167).

Proximity limit switch installations include only three parts:

- Sensing head located where magnetic pieces will actuate the element when brought within the predetermined trip distance;
- Control element picks up the signal from the head and drives static control components, relays or solenoids;

 115 v, 60 c, supply line and head-to-element lead. Normally each sensing head requires its own control element, although in special applications up to six heads can be used on a single element.

OPERATING PARAMETERS:

Two operating distances: Adjustable ½"—½"; ½"—2". 5-20 operations per second. Response time, 25 milliseconds. Sensitivity to turn off: 20% at maximum trip distance; 5% at minimum trip distance. Control element output: 8 w, 24 v d-c at 335 ma, 60 cps.

For specific or test applications, send your order or request for further technical information direct to General Purpose Control Dept., P.O. Box 2025, Buffalo 5, N.Y.

You can be sure . . . if it's Westinghouse.

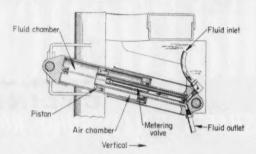


NOTEWORTHY

Patents

Air-Spring Suspension

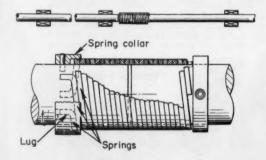
Collapsible struts located between a vehicle body and the housing of each individual wheel provide an airspring suspension system. The strut is fitted with a fluid chamber into which hydraulic fluid is fed under pressure. At the same time, fluid is drained from this chamber to a second chamber (not shown), having a pneumatically loaded resilient wall. Upon compression



of the strut chamber, hydraulic fluid flows into the second chamber forcing the resilient wall outward against pneumatic pressure. When the load is released, pneumatic pressure forces the fluid from the second chamber back into the strut chamber. The flow of fluid from the strut chamber is damped by a double-acting metering valve to prevent continued oscillation. Patent 2,957,702 assigned to Thompson Ramo Wooldridge Inc., by John P. Heiss.

Triple-Spring Coupling

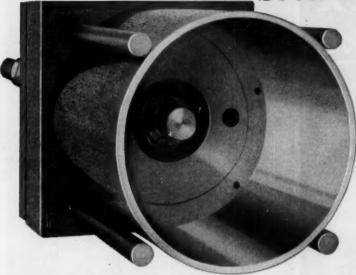
Three interwound helical springs provide a flexible connection for long shafts requiring two or more bearings. Springs are held in position at one end of the coupling by a shaft collar fitted to receive the spring



lugs. Opposite spring ends are free. This arrangement provides a torsionally rigid connection in one direction of rotation and a torque-limiting connection in the op-

Zone

SCORING RESISTANCE...



HYDRO-LINE CYLINDERS and cylinder life are increased by new chrome-plated barrel ID's on Hydro-Line Series R2 cylinders. Hard chrome-plating resists scoring, even under critical side loads. Corrosion is eliminated, even where condensation is unusually severe.

Laboratory endurance tests proved to us that these chrome-plated barrels designed into heavy-duty cylinder applications will decrease machine downtime and maintenance costs.

Standard on Series R2 air cylinders to 200 psi; hydraulic cylinders to 2500 psi; bore sizes from 1½" to 12" all ready for immediate delivery. See your Hydro-Line representative for details.

5602 PIKE ROAD, ROCKFORD, ILLINOIS, manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • boosters • adjustable-stroke cylinders • dispensing cylinders • single-acting cylinders • rod end couplers

Circle 377 on Page 19



Because Quick Disconnects are the fastest, easiest and most economical means of making or breaking a connection. They pay for themselves by reducing costly set-up time and maintenance costs.

A simple, one-hand operation—connect or disconnect lines instantly. No turning or twisting. Eliminates costly "wrench type" connections. Step-up production.

The Series "D" (2D & 4D) Couplings are **interchangeable** with all popular makes. A small, rugged lightweight coupling for air, liquids and gases. Designed for instrumentation, aircraft and industrial uses. Construction and performance meets Military Specification MIL-C-4109A.

Patented **PUSHOMATIC** locking forms a positive highpressure and leak-proof connection. Buna N seals assure positive sealing. Shut-off valve in socket stops the flow when disconnected. Working Pressures to 7500 PSI.

The Series "D" has these advantages

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g 360° Swivel action ion Integral shut-off valve Interchangeability

Four end types in pipe sizes 1/8" through 3/4" N. P. T. Write for Interchangeable Coupling Bulletin 1500.

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GRC's unique high speed, automated methods give you high quality, uniformly accurate small parts in die cast zinc alloy or molded Delrin, Nylon and other engineering thermoplastics . . . at lew cost. GRC experience and exclusive techniques open the way to new design freedom, new production and assembly shortcuts. Write, wire, phone NOW for samples and detailed bulletins. Send prints for prompt quotation.

NO MINIMUM SIZE! Maximum sizes: Zinc Alloy—2" long, ½ oz. Plastic—1¼" long, .03 oz.



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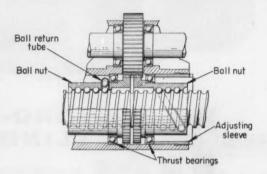
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posite direction. Because the free ends can have any desired degree of preloading within the elastic limit of the spring stock, considerable torque can be transmitted before overrun of the spring coils occurs. Patent 2,979,925 assigned to Curtiss-Wright Corp., Cleveland, Ohio, by Philip C. Hungerford, Jr.

Antibacklash Ball-Screw Assembly

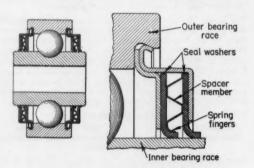
Backlash in a ball-screw mechanism is eliminated by an adjusting sleeve which preloads the balls through interacting thrust bearings. The left thrust bearing is axially fixed; the right thrust bearing is free to move within the bore. Inward movement of the adjusting



sleeve is transmitted to the right ball nut through the movable thrust bearing. Since the position of the left ball nut is fixed, this relative movement axially loads the shaft balls in opposite directions. Backlash between the nuts and the ball race in the shaft is eliminated. Patent 2,978,920 assigned to Beaver Precision Products Inc., Clawson, Mich., by Richard E. Sears and Walter H. Morris.

Double-Guard Bearing Seal

Two resilient seal-washers are distorted against the inner bearing race of an antifriction bearing to provide double-guard protection. The seal washers are separated by a truss-shaped spacer. Spring fingers on the spacer



act against the inner primary seal to provide a pressure-tight contact. The outer secondary seal prevents contaminating particles from reaching the inner bearing seal. Patent 2,979,345 assigned to Fafnir Bearing Co., New Britain, Conn. by Howell L. Potter.







New! Space savingest relay you've ever seen: New Cutler-Hammer "Compact 300"

Cutler-Hammer's new, versatile 300 volt 6 amp., industrial control relay is so reliable it's permanently sealed. Bifurcated contacts add even more millions of operations.

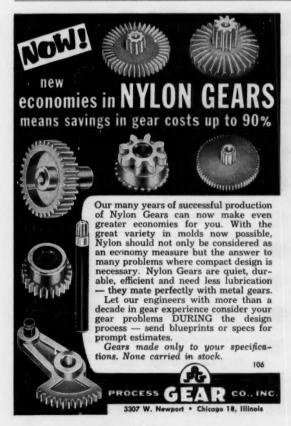
So compact you can get 8 circuits in a panel space only 2" wide by 2¾" high. 2, 3, 4, 6, 8 poles with any combination of N.O. or N.C. contacts available. Add new "mechanical memory" latch at any time. Same life as relay. Get full details in PUB. L079-L243.

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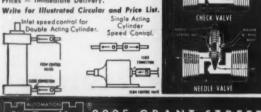
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Presu-Tral Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the apposite direction. Retro ball floats in most sensitive position to sect, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — Val" to 34". Valve badies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.



FLOW CONTROL VALVE

2925 GRANT STREET

Circle 384 on Page 19



A most efficient and accurate variable speed drive—

34 hp. to 10 hp. Low cost, easily installed, little or no maintenance.

Check its many advantages!

Write for Bulletin No. 95



can give your machines widerange speed control on fixed centers — ratios up to 8:1—capacities from ½ hp. to 10 hp. Used by many industries in a variety of applications. Rugged, efficient, economical, simple to use.

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SK FLOW INDICATOR PROVIDES DUAL SCALE FOR WATER OR AIR Now, you can obtain approximate measurement of water flow in gpm and air flow in cfm with SK's Fig. 18123 Ball Flow Indicator. Note the dual scale, for water and air, on the Flow Indicator in the illustration. This indicator uses a ball to indicate flow in a pipe line. The position of the ball, in relation to the water or air scale graduations gives approximate indication of fluid rate-of-flow SK Fig. 18123 Ball Flow Indicators, made of

bronze, are carried in stock in 1/4, 1/2, 3/4, 1, 1 1/2,

and 2 in. pipe connection sizes.



For Immediate Delivery, Standard SK Jet Ejectors, Rotameters, and Flow Indicators are stocked in Cornwells Neights (Phila.), Pa., Houston, Texas, and San Francisco, Calif.

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STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA

Circle 385 on Page 19

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PARTS? MATERIALS? COMPONENTS? FINISHES?

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USE THE YELLOW CARD ON PAGE 19.

THE AMPLEXOLOGIST

eliminates the scrap

The part shown is a magnet body for an electromagnetic clutch. Because of the required magnetic properties, uniform wall density is highly critical. Previously, therefore, it was necessary to machine the entire part. The Amplexologist, however, designed it to be produced as a finished, precision powder metal part which requires no machining; and through advanced density control held specified magnetic properties, even in the counterbore. Approximate saving, 94%.



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Circle 389 on Page 19

SPEAKING OF OSURES A certain ancient Bond Street tailor introduced a novel line of clothing with

the slogan "our suits wear like iron." Since his customers

seemed to live longer, he developed a very, very loyal following.

Invariably purchasers of MEK electrical enclosures become very, very loyal when they see the extra quality and long lived ruggedness built into every unit. Our latest catalog tells the who



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THE JOYCE-CRIDLAND COMPANY, DAYTON 3, OHIO Rush folder on Worm Gear Screw Jacks!

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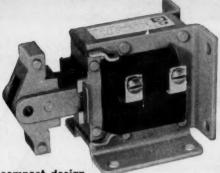


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NEW compact design greater pull-power...20% faster cycling

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- · Double T plunger design gives more-level pull characteristics without power drop-off
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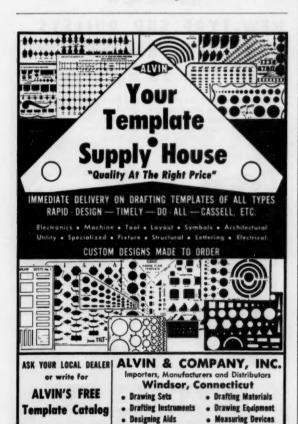
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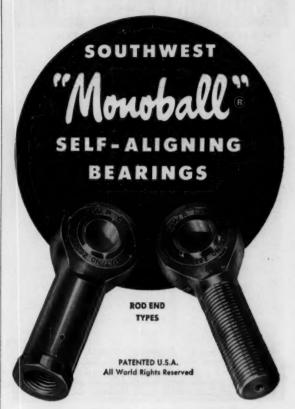


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APPLIANCE AND AUTOMOTIVE DIVISION

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- Stainless Steel Ball and Race
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Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Our engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. Write for Engineering Manual No. 551. Address Dept. MD-61.

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Plug-in relays, receptacles for plug-in connection of lamps and cells. Additional Plug-in accessories include counters and time delays. MINIATURIZED

Small, for "tight-spot" installation, yet rugged for long service. Accurate, for precise automatic control in virtually any industry.

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Plug-in terminals available for quick connection to any of a wide range of Amplifiers. This design enables you to select the most economical amplifier for your job requirements.

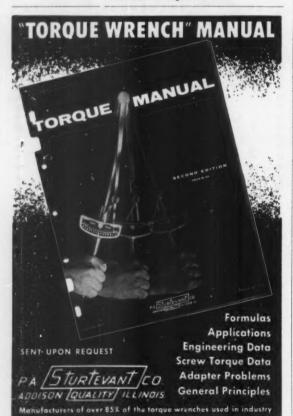
INEXPENSIVE

Standard Set P-5 is \$17. Set P-5S is \$21. Amplifiers start at \$39.50. For complete data, write for Brochure YP-6

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Circle 398 on Page 19



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Circle 399 on Page 19

NEW-TYPE FHP PULLEYS AND SPEED REDUCERS SAVE YOU 33% PER UNIT

You can now cut costs on fractional horsepower equipment of all kinds with these unique, metal and nylon-fiberglass products. Rampe Variable Pitch Pulleys and Speed Reducers wear longer, run quieter, and cost less. Savings are 33% or more per unit in lower initial cost and added chemical resistance, impact strength, self-lubrication for hard-to-reach applications.



Speed Reducers

Complete line includes gear ratios up to 1500 to 1. Machined steel worm gear drive shaft, choice of aluminum or nylon output gear, in fiberglass reinforced case. 1/4" solid or hollow shaft. Model SW-1, for applications up to 1/4 hp.





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Learn how TA's new predesigned Instrument Cases solve your equipment housing problems

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 Precision quality.

 Reinforced aluminum construction.

- 10. Reinforced aluminum construction.

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INSTRUMENT MANUFACTURERS: If you make portable instruments or equipment, you can't afford not to investigate the TA line.

TA Cases come in a diversity of standard lid sizes, and are sold at proprietary prices. During assembly the depth can be cut to your exact specifications. Or, if you like, TA will furnish you free vellums and templates so you can save your-self money by designing your product to fit one of the many standard sizes.

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Circle 402 on Page 19



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Hi-Temperature Finish





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BHEW's HOLLOW ROD CYLINDERS are two piece tubular rods that allow oil to flow through the rod in two separate channels to operate double-acting cylinders. You benefit from this application because the cylinder barrel is plain without port connections and the rod is anchored in a stationary position. The barrel is the reciprocating member.

Eliminates hydraulic line connections to the cyl-Inder barrel • Especially successful for boom ex-tenders, out-riggers, etc. • Hollow rod cylinders are partially constructed around standard components.

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your specific product applications. You benefit from production economies; you get custom-built cylinders.

Let's discuss your design and application problems --

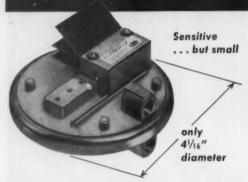
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MICHIGAN CITY, INDIANA

Circle 405 on Page 19

IDEAS! for heavy equipment designers



Looking for new solutions to heavy-duty power problems? This new brochure has full information on heavy-duty transmissions with input torque capacities of 150 to 2500 ft-lb. Included is "idea material" describing:

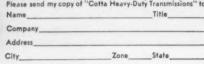
Standard transmissions customized to each application
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Examples of single-speed, multiple-speed and right

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MAYLINE CO., INC. 601 No. Commerce St.

Sheboygan, Wisconsin



4-POST TABLE WITH DRAWERS

- MAYLINE

Circle 406 on Page 19



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200 STANDARD SHUNT AND SERIES MODELS

1/35 to 1/10 hp.

Then switch to Carter Chlassic



Interchangeable with competitive types. Exclusive performance features include longer brush life, instrument quality ball bearings in steel sleeved housings, highest quality die-cast construction.



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6 to 220v. Series Models . 6 to 115v. DC Shunt Models

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WRITE for prices, specifications, OEM discounts.

Use letterhead for special attention.

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W. George Street • Phone JU 8-7700 • Chicago 18, Illi Large Enough to Serve You, Small Enough to Want to

Circle 409 on Page 19



Every Abart gear is precision-cut to the customer's exact specifications. We carry no stocks!

Abart has complete gear-cutting facilities to promptly supply the exact gear you want - spiral, bevel, helical, internal, worm, rack and sprocket - in any quantity, any material, from 5/7 D. P. to 96 D P .- 1/4" P. D. to 18" P. D.

Send B/P or specs. Ask for quote.

Write for Abart Gear Bulletin

GEAR and

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CHICAGO 50, ILLINOIS

Circle 410 on Page 19



compact, space-saving and easily installed

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Clearwater, Fla.1954 Jeffords Dr. H. G. ROWLAND, Dial 441-4121 Dallas 35818 Exchange Bank Bldg. JAMES H. CASH, Fleetwood 1-4523

London, S.W. 12 Caxton St., Westminster

Published by

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. O'ter countries: One year, \$25. Published every ather Thursday by The Penton Publishing Co., Penton Bidg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.





backtalk-

-Sequel

The happy man trying on his new boat is Earl F. Wilson, a design engineer for Commonwealth Associates, Jackson, Mich. The boat is a 16-ft aluminum Starcraft, which Franklin Electric Co. awarded—with a 40-hp outboard



motor—as first prize in a contest to name its new aluminum motor. Mr. Wilson read about the contest in Machine Design (it was described in an advertisement and on this page); he and some 1600 other engineers submitted entries.

This summer, Mr. and Mrs. Wilson and the three small boating enthusiasts will be joined by two more offspring in using the boat and the water skis which Papa bought to go with his prize.

-Keeping Up

An alma mater that takes a truly motherly interest in its graduates, Carnegie Institute of Technology acknowledges an awareness of the "responsibility a university has in the continuing education of its alumni." To discharge this responsibility, the Alumni Federation and the faculty of Carnegie Tech have initiated an allday Carnegie Conference, the first to be held June 10. The program will include discussions of new developments in the fields of engineering, science, business, fine arts, liberal arts, and social sciences.

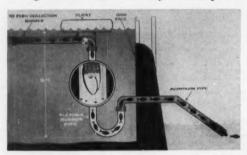
Eight symposia and twelve lectures are scheduled; more than 500 alumni will come to Pittsburgh for the conference. Engineering graduates will hear J. Fletcher Osterle, professor of mechanical engineering, deliver a lecture on "Direct Energy Conversion, Thermodynamic Explanations."

-Not-So-Close Inspection

In our May 11 issue, Page 34, we printed a picture and caption on a gamma-ray image intensifier system which permits continuous inspection of 4-in. thick steel plate and other dense materials. We could have used such a machine—a rather large flaw in our copy went undetected until after the page was printed. We said the system was developed by Rauland Corp., subsidiary of Picker X-Ray Corp. To set the record straight, the two companies responsible for the development are Rauland Corp., a subsidiary of Zenith Radio Corp., and Picker X-Ray Corp.

-Fish Story

Everybody is familiar with the salmon and the events in its life cycle that cause it to travel upstream and downstream. However, most of us don't know what happens when something stops the salmon. Like a dam. This problem confronted the Puget Sound Power and Light Co., which recently constructed a dam across the Baker River in Washington. To avoid collecting a reservoirful of one-way fish, the power



company engaged Stone & Webster Engineering Co. to build a piscatorial transportation system. The fish are collected in a special barge, pumped through a flexible hose through the dam, and released downstream.

A design problem—finding the right hose to withstand pressure 70 ft below the water line—was brought to Hewitt-Robins. Because external pressure is not a common consideration in specifying hose, the company didn't have information on such performance, so it built a pressure vessel in which water pressures could be regulated and hose under test could be observed through a window. A proper hose was specified and installed, and now life goes on for the salmon.

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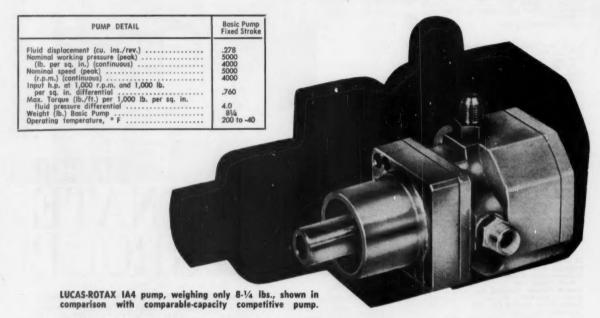






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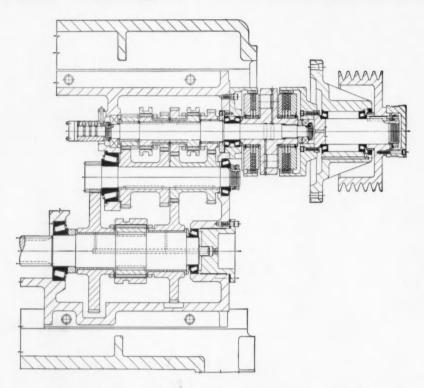
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Bullard fully powered vertical turret lathe uses Timken® bearings to maximize production



When designing their Dynatrol® Vertical Turret Lathe, Bullard engineers' aim was to increase machine speed and output economically. Dynatrol provides single lever or remote control of all head motions, traverse and feed engagement. And Timken® tapered roller bearings at vital points—table radial position, headstock, clutch shaft, input pulley, rail raising bracket—provide the load-carrying capacity under varying loads and speeds that assures maximum production. Their taper lets Timken bearings take *any* combination of radial and thrust loads. And precision manufacture of Timken bearings assures high precision in the machine.



engineering service that saves you time and money. Working with you at the design stage, our sales engineers can often solve your bearing problems on the spot. From the wide range of Timken bearing sizes, types and precisions they can help you select the Timken bearings to give you the maximum in efficient, economical design engineering.



The Timken Roller Bearing Company, Canton 6, Ohio. Cableaddress: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

